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# DEFENSE INFRASTRUCTURE

## Navy Can Improve the Quality of Its Cost Estimate to Homeport an Aircraft Carrier at Naval Station Mayport



G A O

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Highlights of [GAO-11-309](#), a report to congressional committees

## Why GAO Did This Study

The 2001 Quadrennial Defense Review called for the Navy to provide more warfighting assets more quickly to multiple locations. Subsequently, the Navy made a preliminary decision to homeport a nuclear-powered aircraft carrier at Naval Station Mayport, Florida, which was affirmed by the 2010 Quadrennial Defense Review.

In House Report 111-491, accompanying a proposed bill for the Fiscal Year 2011 National Defense Authorization Act (H.R. 5136), GAO was directed to develop an independent estimate of the total federal costs for the proposed homeporting. GAO's objectives were to (1) develop an independent estimate of the full life-cycle costs to homeport a nuclear aircraft carrier at Mayport and (2) determine to what extent the Navy's estimate meets the characteristics of a high-quality cost estimate. To do this, GAO worked with a firm experienced in preparing life-cycle cost estimates for major federal acquisitions and compared the Navy's cost estimating practices with the best practices in GAO's *Cost Estimating and Assessment Guide*.

## What GAO Recommends

GAO recommends DOD take several actions to improve the quality of its Mayport cost estimate. DOD partially concurred with two recommendations and disagreed with one, generally stating that additional direction or change is not required. GAO believes the recommendations remain valid as discussed in the report.

View [GAO-11-309](#) or key components. For more information, contact Brian Lepore at (202) 512-4523 or [leporeb@gao.gov](mailto:leporeb@gao.gov).

## DEFENSE INFRASTRUCTURE

### Navy Can Improve the Quality of Its Cost Estimate to Homeport an Aircraft Carrier at Naval Station Mayport

## What GAO Found

GAO's independent cost estimate suggests that the total one-time cost of homeporting a nuclear-powered aircraft carrier at Naval Station Mayport is expected to be between \$258.7 million and \$356.0 million, in base year 2010 dollars. The Navy's estimate of the one-time cost is \$537.6 million—also in base year 2010 dollars—which is outside the upper range of GAO's estimate. Unlike GAO's estimate, the Navy did not conduct a risk and uncertainty analysis on its one-time costs; as a result, its estimate does not include a range. The largest difference between GAO's estimate of one-time costs and the Navy's estimate is the cost of constructing new facilities at Mayport. Based on the historical costs of constructing similar facilities, GAO estimates at the 65 percent confidence level that the cost for constructing the controlled industrial facility will be \$70.5 million, and the cost for constructing the ship maintenance support facilities will be \$45.6 million. The Navy estimates the construction costs to be much higher at \$139.1 million and \$157.2 million, respectively. Navy officials told GAO the difference is due to the increased cost involved in protecting the buildings from a potential storm surge associated with a Category 4 hurricane. GAO included a hurricane factor in its estimate to account for this increase, but GAO and the Navy used different estimating methods in developing the estimates for the construction costs. GAO used adjusted actual costs from similar construction projects, while the Navy used a detailed engineering estimate. For recurring costs, GAO's independent cost estimate suggests that the total is expected to be between \$9.0 million and \$17.6 million per year. The Navy's estimate of \$15.3 million per year is within GAO's estimated range.

The Navy's estimate did not fully meet any of the four characteristics—comprehensive, accurate, well documented, and credible—for producing a high-quality cost estimate. Specifically, although the estimate included almost all of the life-cycle costs related to homeporting a nuclear aircraft carrier at Mayport, it partially met the criteria for being comprehensive because it does not fully describe the cost-influencing ground rules and assumptions. The estimate was only minimally accurate and well documented in that although many elements of the estimate are based on actual experiences from other comparable programs, it is difficult to say if the cost estimates are the most likely costs since the Navy did not conduct a risk and uncertainty analysis. Further, the estimate contains very little step-by-step description of how the estimate was developed so that a cost analyst unfamiliar with the program could independently replicate it. The Navy had to recreate several portions of the estimate in order to provide GAO with supporting documentation. Further, the Navy's estimate does not meet the GAO best practice for a credible estimate because it does not include a sensitivity analysis and was not compared by the Navy to an independent cost estimate conducted by a group outside the Navy. Without fully meeting the characteristics of a high-quality estimate, the Navy's ability to present a convincing argument of the estimate's affordability and credibly answer decision makers' and oversight groups' questions about the estimate is hampered.

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United States Government Accountability Office  
Washington, DC 20548

March 3, 2011

## Congressional Committees

Until the *U.S.S. John F. Kennedy*—a conventional aircraft carrier—was retired in 2007, the Navy had homeported at least one aircraft carrier at Naval Station Mayport, Florida<sup>1</sup> for many decades. Prior to the *U.S.S. John F. Kennedy*'s retirement, the 2001 Quadrennial Defense Review called for the Navy to provide more warfighting assets more quickly to multiple locations and to meet this requirement, the Navy made a preliminary decision to homeport additional surface ships at Mayport. The Navy subsequently prepared an environmental impact statement to evaluate a broad range of strategic homeport and dispersal options for Atlantic Fleet surface ships in Mayport and on January 14, 2009, issued its decision to pursue an option that would include homeporting a nuclear-powered aircraft carrier at Mayport. The Navy's decision was reviewed as part of the Department of Defense's (DOD) 2010 Quadrennial Defense Review, which in its report supported the Navy's decision to homeport a nuclear-powered aircraft carrier in Mayport, indicating that homeporting an East Coast carrier in Mayport would contribute to mitigating the risk of a terrorist attack, accident, or natural disaster.<sup>2</sup> Additionally, officials in DOD's Office of Cost Assessment and Program Evaluation, which was part of the review's working group assessing the Navy's Mayport decision, reviewed the Navy's presentations and supporting documentation, but did not develop an independent cost estimate for comparison.

In House Report 111-491, accompanying a proposed bill for the Fiscal Year 2011 National Defense Authorization Act (H.R. 5136), the House Committee on Armed Services directed GAO to submit a report no later than February 15, 2011,<sup>3</sup> that contains an independent estimate of the total

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<sup>1</sup> Naval Station Mayport is located northeast Florida, on the Atlantic Coast, near Jacksonville. It is roughly 469 nautical miles south-southwest of Norfolk, Virginia.

<sup>2</sup> In our report examining the military services' processes for making basing decisions for force structure within the United States, we provide information about the approach used by the Navy in making its decision to homeport a nuclear-powered carrier at Mayport, Florida. See app. II of the report. GAO, *Defense Infrastructure: Opportunities Exist to Improve the Navy's Basing Decision Process and DOD Oversight*, [GAO-10-482](#) (Washington, D.C.: May 11, 2010).

<sup>3</sup> We provided the draft report to DOD and the congressional defense committees on January 21, 2011, and agreement was made that we issue the report at a later date.

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direct and indirect costs<sup>4</sup> to be incurred by the federal government for the proposed homeporting at Naval Station Mayport.<sup>5</sup> In response to this report, our objectives were to (1) develop an independent estimate of the full life-cycle costs associated with the Navy's plan to establish a second East Coast homeport for a nuclear-powered aircraft carrier at Naval Station Mayport and determine to what extent it differs from the Navy's estimate and (2) determine to what extent the Navy's estimate meets the characteristics of a high-quality cost estimate.

To develop the independent cost estimate, we worked with an outside cost estimating consulting company with expertise in preparing estimates of the life-cycle costs of major federal acquisitions. We followed the 12 steps outlined in the *GAO Cost Estimating and Assessment Guide*,<sup>6</sup> which have been identified as best practices by GAO and experts in the cost estimating community, to develop a risk-adjusted range of cost estimates. We compared our risk-adjusted range of estimates, at an 80 percent confidence interval, to the Navy's point estimates to determine whether the Navy's estimates were within our risk-adjusted range.<sup>7</sup> For a direct element-by-element comparison between our estimate and the Navy's, we also compared our estimates at the 65 percent confidence level with the

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<sup>4</sup> We define these costs as full life-cycle costs, which are the net one-time and recurring costs, both direct and indirect, that will be incurred by the Navy in homeporting a nuclear-powered aircraft carrier in Mayport.

<sup>5</sup> H.R. Rep. No. 111-491, at 507 (2010). House Report 111-491 also directed GAO to submit two additional reports on homeporting a nuclear-powered aircraft carrier in Mayport. See H.R. Rep. No. 111-491, at 254 and 260-261. This includes GAO, *Depot Maintenance: Navy Has Revised Its Estimated Workforce Cost for Basing an Aircraft Carrier at Mayport, Florida*, GAO 11-257R (Washington, D.C.: Mar. 2011) and a report on the ship repair industrial base in northeast Florida that also will be released in March 2011.

<sup>6</sup> GAO, *GAO Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Capital Program Costs*, [GAO-09-3SP](#) (Washington, D.C.: Mar. 2009).

<sup>7</sup> A point estimate represents the best guess or most likely value for the cost estimate, given the underlying data. A confidence interval describes a range of possible costs, based on a specified probability level. The low and high values of the confidence interval can be expressed as confidence levels that represent the probability that the point estimate will be met. Our 80 percent confidence interval is the range of costs from the 10 percent confidence level to the 90 percent confidence level. At the 10 percent confidence level, there is a 10 percent chance that the cost will be at or below the estimate and a 90 percent chance that the cost will be above the estimate. Likewise at the 90 percent confidence level, there is a 90 percent chance that the cost will be at or below the estimate and a 10 percent chance that the final cost will be above the estimate. Because the Navy did not conduct a risk analysis, it is not able to identify the confidence levels of its estimates.

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Navy's point estimates.<sup>8</sup> Additionally, we reviewed the Navy's cost estimate and interviewed Navy officials with knowledge of the methodology and key underlying assumptions used in developing the Navy's estimate.<sup>9</sup> We reviewed the Navy's environmental impact study used in evaluating options for homeporting surface ships at Mayport. We also obtained background information about nuclear-powered aircraft carrier maintenance, visited locations where nuclear-powered aircraft carrier maintenance is performed, and spoke with Navy officials knowledgeable about the personnel and facilities requirements for nuclear-powered aircraft carrier maintenance. From this information we developed a list of individual cost elements and used standard cost estimating methodologies to estimate the cost of each element.<sup>10</sup> We also conducted sensitivity and risk and uncertainty analyses on our estimate.<sup>11</sup> We compared our estimate with the Navy's and interviewed Navy officials to determine the reasons for any differences. Through document reviews and interviews with agency officials knowledgeable about the Navy's cost data and the systems that produced them and the internal controls used to maintain the integrity of the data, we determined the data were sufficiently reliable for our purposes.

To determine to what extent the Navy's estimate has the characteristics of a high-quality cost estimate, we compared the Navy's cost estimating practices against those outlined in the *GAO Cost Estimating and Assessment Guide*. We analyzed the extent to which the Navy's cost

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<sup>8</sup> In accordance with the principles outlined in the *GAO Cost Estimating and Assessment Guide*, the 65 percent confidence level is appropriate for budgeting decisions.

<sup>9</sup> Our analysis is based on the most recent cost estimate documentation that has been provided to us by the Navy. That documentation consists of a report from the Chief of Naval Operations transmitted to the congressional defense committees on December 28, 2010, plus two DOD information papers dated February 25, 2010, and August 5, 2010. The December 2010 report provides the Navy's estimate of both one-time and recurring costs, while the February 2010 information paper provides only the one-time costs and the August 2010 information paper outlines just the recurring costs. See app.I for more information.

<sup>10</sup> Our cost estimating methodologies primarily included parametric estimates and scaled analogies. A parametric estimate is a method that uses an established relationship between cost and one or more input variables. The input variables become parameters in an equation that is used to predict cost. Scaled analogy is a cost estimating method that relies on using actual costs from analogous projects.

<sup>11</sup> Sensitivity analysis examines the effect of changing one assumption or cost input at a time while holding all other variables constant. A risk and uncertainty analysis provides a way to assess the variability in the cost estimate and provides a range of possible costs along with a level of confidence in achieving the most likely cost.



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estimate was (1) comprehensive, (2) accurate, (3) well documented, and (4) credible—the four key characteristics of high-quality cost estimates and assigned each characteristic a rating of not met, minimally met, partially met, substantially met, or met.<sup>12</sup> More detailed information about our scope and methodology is provided in appendix I.

We conducted this performance audit from July 2010 to February 2011 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings, and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

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## Background

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### Planned Infrastructure and Facility Improvements at Naval Station Mayport to Support a Nuclear-Powered Aircraft Carrier

The U.S. Navy currently maintains 11 nuclear carriers—5 homeported on the West Coast of the United States, 5 on the East Coast of the United States, and 1 in Yokosuka, Japan. Of the West Coast carriers, 3 are homeported in San Diego, California; 1 in Bremerton, Washington; and 1 in Everett, Washington. All 5 East Coast carriers are homeported in Norfolk, Virginia. As some of the most technologically advanced ships in the world, nuclear-powered aircraft carriers require continuous and regularly scheduled maintenance to keep them ready to meet mission requirements.

Naval Station Mayport has served as a conventional aircraft carrier homeport at various times since the 1950s, including homeporting two conventional carriers at one time, but it has not served as homeport for a nuclear-powered aircraft carrier. Consequently, to homeport a nuclear powered aircraft carrier, several major infrastructure upgrades are required at Mayport. These infrastructure improvements include construction of four new buildings: (1) controlled industrial facility, (2) ship maintenance facility, (3) maintenance support facility, and (4) parking garage. The controlled industrial facility would be used for the

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<sup>12</sup> Not met means the Navy provided no evidence that satisfies any of the criterion; minimally met means the Navy provided evidence that satisfies a small portion of the criterion; partially met means the Navy provided evidence that satisfies about half of the criterion; substantially met means the Navy provided evidence that satisfies a large portion of the criterion; and met means the Navy provided complete evidence that satisfies the entire criterion.

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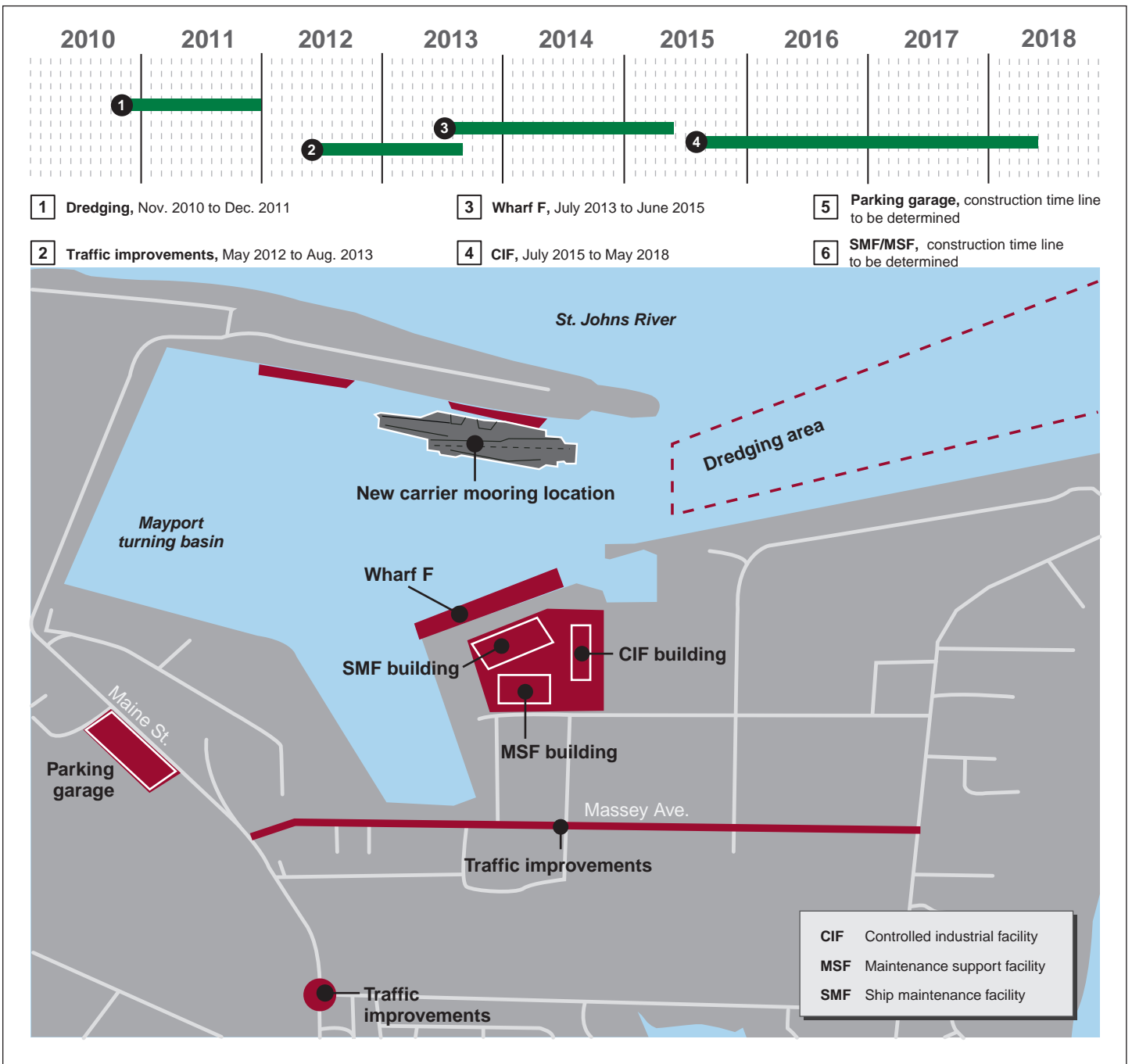
inspection, modification, and repair of radiologically controlled equipment and components associated with naval nuclear propulsion plants. The ship maintenance facility is necessary to perform nonnuclear maintenance on the carrier's nuclear propulsion plants. The maintenance support facility would provide the needed administrative and technical staff offices to support propulsion plant maintenance and a central area for receiving, inspecting, shipping, and storing materials. The parking garage would replace parking spaces lost through construction of the three new maintenance buildings. The infrastructure upgrades also include improvements to Wharf F, which would receive improvement to its structural components, berthing capability, and utility and security systems in order to make it capable of homeporting a nuclear carrier. Additionally, traffic improvements would be made to the Massey Avenue corridor to rebuild a boulevard-style roadway with two lanes each way divided by a grass median.<sup>13</sup> Dredging would also be necessary to deepen the Mayport turning basin to allow access for a fully loaded nuclear aircraft carrier.<sup>14</sup> Figure 1 shows the location and expected time line for completion of the planned infrastructure and facility improvements at Naval Station Mayport.

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<sup>13</sup> In addition to the road improvements on Naval Station Mayport, information provided by a Department of Transportation official indicates that the Jacksonville Transportation Authority, based on its study of traffic improvements to the intersection approaching the main gate outside of the naval station, has identified up to \$8 million in improvements that are unfunded at this time. The official indicated that these improvements are potentially eligible for federal-aid funds.

<sup>14</sup> Dredging is necessary to make the Mayport basin accessible at all times for a nuclear-powered aircraft carrier and would have to be done whether a carrier is homeported at Mayport or not. Although Naval Station Mayport is not currently capable of homeporting a nuclear carrier, nuclear carriers do visit for short periods of time but can only access the base with a light load and only during high tide due to the depth of the turning basin.

**Figure 1: Location and Timeline for Completion of Planned Infrastructure and Facility Improvements at Naval Station Mayport**



Source: GAO analysis of Navy's Final Environmental Impact Study for the Proposed Homeporting of Additional Surface Ships at Naval Station Mayport and military construction budget documents.

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## Navy's Estimate for Establishing a Nuclear-Powered Aircraft Carrier at Naval Station Mayport

The Navy's estimate of one-time and recurring costs for establishing a nuclear-powered aircraft carrier homeport at Naval Station Mayport is contained in two DOD information papers dated February 25, 2010, and August 5, 2010.<sup>15</sup> The February 2010 information paper was produced by the Navy's Office of the Chief of Naval Operations in response to a request from the Congressional Research Service and provided only the one-time costs of the carrier homeport. Those one-time costs were primarily drawn from a series of DD Form 1391s, which DOD uses as budget justification material to support funding requests for military construction. However in addition to military construction costs, there are also one-time costs associated with planning and design, the initial equipment outfitting for the new maintenance facilities to be built in Mayport, and the permanent change of station cost for the relocation of the carrier crew to Mayport.

The August 2010 information paper was also prepared by staff working for the Chief of Naval Operations, in response to questions from GAO about the recurring costs for the planned homeporting. This information paper contained estimates of the recurring costs associated with the carrier homeport. There were nine recurring costs listed in the information paper including: (1) permanently assigned labor for the new maintenance facilities, (2) base operating support, (3) facilities sustainment, (4) facilities restoration and modernization, (5) transportation of equipment for the carrier air wing, (6) travel and per diem for public shipyard workers traveling from Norfolk to Mayport to work on the carrier's nuclear propulsion systems, (7) the additional biennial maintenance dredging needed to allow access for a fully loaded nuclear aircraft carrier, (8) the differential between Norfolk and Mayport in basic allowance for housing costs, and (9) the differential between Norfolk and Mayport in utilities costs. The recurring costs do not represent the total cost of operating a nuclear-powered aircraft carrier. Rather, they are the subset of costs associated with nuclear carrier maintenance in which there is a cost differential between conducting the maintenance in Mayport and conducting the maintenance in Virginia.

On December 28, 2010, the Chief of Naval Operations transmitted a report to the congressional defense committees that essentially consolidated the

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<sup>15</sup> Department of the Navy, Report to Congress on Naval Station Mayport, Florida Homeporting Alternatives (Washington, D.C.: Dec. 28, 2010). Department of Defense, Information Paper Responding to Questions from the Government Accountability Office (Washington, D.C.: Aug. 5, 2010). Department of Defense, Information Paper Responding to Questions from Congressional Research Service (Washington, D.C.: Feb. 25, 2010).

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estimates provided in the two information papers.<sup>16</sup> However, the report differed from the information papers in its treatment of inflation for one-time costs and in the total for the one-time permanent change of station cost. The February 2010 information paper showed the one-time military construction costs as budgeted amounts in then-year dollars, which include the effects of inflation, while the December 2010 report showed all one-time cost in base year 2010 dollars, which exclude the effects of inflation and use 2010 prices throughout the life cycle. The one-time permanent change of station cost was reduced from \$26 million to \$10 million in the December 2010 report. The report did not provide any additional description or documentation that was not contained in the two DOD information papers.

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## Characteristics of a High-Quality Cost Estimate

A reliable cost estimate is critical to the success of any program because it can provide the basis for informed investment decision making, realistic budget formulation and program resourcing, meaningful progress measurement, proactive course correction when warranted, and accountability for results. In March 2009, GAO issued a cost estimating and assessment guide that compiled cost estimating best practices drawn from across industry and government. Specifically, the guide includes four characteristics of a high-quality cost estimate by which an organization's management can assess cost estimates in making informed decisions. A cost estimate is:

- *comprehensive* when it accounts for all possible costs associated with a project, is structured in sufficient detail to ensure that costs are neither omitted nor double-counted, and the estimating teams' composition is commensurate with the assignment;
- *well documented* when supporting documentation is accompanied by a narrative explaining the process, sources, and methods used to create the estimate and contains the underlying data used to develop the estimate;
- *accurate* when it is based on an assessment of the costs most likely to be incurred and not overly conservative or too optimistic; and
- *credible* when it has been cross-checked with an independent cost estimate, the level of confidence associated with the point estimate has been identified through a risk and uncertainty analysis, and a sensitivity analysis has been conducted—that is, the project has

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<sup>16</sup> The Navy compiled and submitted the report in response to direction from the House Armed Services Committee contained in H.R. Rep. No. 111-491.

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examined the effect of changing one assumption related to each project activity while holding all other variables constant in order to identify which variable most affects the cost estimate.

In addition, GAO's cost estimating and assessment guide lays out 12 key steps that, when followed, should result in high-quality cost estimates that are comprehensive and accurate and that can be easily and clearly traced, replicated, and updated. The guide also contains hundreds of best practices drawn from across industry and government for carrying out these steps. Table 1 shows these 12 key steps and how they relate to the four characteristics of a high-quality cost estimate.

**Table 1: Twelve Steps of a High-Quality Cost Estimate and Corresponding Characteristics**

Key cost estimating step	Characteristic
Define the estimate's purpose	Well documented
Develop the estimating plan	Comprehensive
Define the program characteristics	Well documented
Determine the estimating structure	Comprehensive
Identify the ground rules and assumptions	Well documented
Obtain the data	Well documented
Determine the point estimate and compare it to an independent cost estimate	Credible and accurate
Conduct a sensitivity analysis	Credible
Conduct a risk and uncertainty analysis	Credible
Document the estimate	Well documented
Present the estimate to management for approval	Well documented
Update the estimate to reflect actual costs and changes	Accurate

Source: GAO.

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## GAO's Independent Cost Estimate Is Lower Than the Navy's Estimate for Homeporting a Nuclear Aircraft Carrier at Naval Station Mayport

Our independent estimate of the total cost for homeporting a nuclear-powered aircraft carrier at Naval Station Mayport is lower than the Navy's estimate. Specifically, the Navy's estimate of one-time costs is outside the upper range of our estimate, while its estimate of recurring costs falls within the upper range of our estimate.

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## GAO Estimates One-Time Costs to Be Between \$258.7 Million and \$356.0 Million, Lower Than the Navy's Estimate

Our independent cost estimate suggests that the total one-time cost of homeporting a nuclear-powered aircraft carrier at Naval Station Mayport will be between \$258.7 million and \$356.0 million, in base year 2010 dollars. The Navy's estimate of the one-time costs is \$537.6 million, also in base year 2010 dollars, which is outside the upper range of our estimate. Unlike our estimate, the Navy did not conduct a risk and uncertainty analysis on its one-time costs; as a result, its estimate does not include a range. Reporting a range of costs around a point estimate is useful to decision makers because it conveys a level of confidence in achieving the most likely cost.

Table 2 shows a comparison between our estimated range and the Navy's estimate for one-time costs. Specifically, the table shows our estimated range at an 80 percent confidence interval and whether the Navy's estimate falls into that range. The low value of the estimate range (\$258.7 million) represents a 10 percent chance that the cost will be that amount or less, and the high value of the estimated range (\$356.0 million) represents a 90 percent chance that the cost will be that amount or less. The last column in the table identifies whether the Navy's estimate is within our estimated range.

**Table 2: Comparison of GAO Estimated Range and Navy Point Estimates of One-Time Costs (in Base Year 2010 dollars)**

(Dollars in millions)

Cost element	GAO's estimated low cost	GAO's estimated high cost	Navy's point estimate	Within GAO's estimated range
Planning and design	15.0	22.9	30.0	No
Dredging	31.3	33.1	46.3	No
Construction				
Parking garage	21.9	53.3	27.8	Yes
Road improvements	9.5	24.3	15.3	Yes
Wharf F improvements	28.3	75.3	38.9	Yes
Controlled industrial facility	35.2	94.9	139.1	No
Ship maintenance support facilities	23.0	59.3	157.2	No
Initial equipment outfitting	24.5	64.4	73.0	No
Permanent change of station for crew	4.7	6.0	10.0	No

Source: GAO analysis.

Notes: The low cost estimate is at the 10 percent confidence level and the high cost estimate is at the 90 percent confidence level. It is not statistically appropriate to add each of the individual confidence intervals to come up with an overall confidence interval. In addition to the road improvements on Naval Station Mayport, information provided by a Department of Transportation official indicates that the Jacksonville Transportation Authority, based on its study of traffic improvements to the intersection approaching the main gate outside of the naval station, has identified up to \$8 million in improvements that are unfunded at this time. The official indicated that these improvements are potentially eligible for federal-aid funds.

Our initial point estimate of the one-time dredging cost based on historical data was \$44.3 million, which was \$2 million less than the Navy's estimate. However, in accordance with the best practices recommended by the *GAO Cost Estimating and Assessment Guide*, we have updated our estimate based on the \$26.6 million contract awarded in August 2010. Our estimated range now reflects the contract award price plus the Navy's overhead and contingency amounts. Navy officials attributed the lower than estimated contract costs to supply and demand within the private dredging sector, which because of lower demand has caused firms to compete at lower cost.

We also compared the Navy's point estimate to our estimate at the 65 percent confidence level. A confidence level is the chance that the actual costs will be equal to or less than the adjusted amount. In table 2, we reported the 10 percent confidence level estimate as our low estimate range and the 90 percent confidence level estimate as our high estimate range. For an element-by-element comparison of our estimate with the Navy's point estimate, we chose the 65 percent confidence level since we consider this confidence level to be an appropriate budgeting range.



Experts agree that program cost estimates should be budgeted to at least the 50 percent confidence level, but budgeting to a higher level, such as 70 percent to 80 percent, or the mean, is now a common practice.

Table 3 shows our 65 percent confidence level estimate in comparison to the Navy's point estimate. To facilitate comparisons against the Navy's estimate, the one-time costs are expressed in base year 2010 dollars, which represent amounts based on 2010 prices, with the impact of inflation removed. While useful for comparisons against the Navy's estimate, base year 2010 dollars should not be used as the basis for budgetary decisions. In order to support a budgetary amount, base year 2010 dollars would need to be converted into then-year dollars.

**Table 3: Comparison of GAO's 65 Percent Confidence Level Estimates and Navy's Point Estimates of One Time Costs (in Base Year 2010 Dollars)**

(Dollars in millions)

Cost element	GAO's 65 percent confidence level estimate	Navy's point estimate	Difference between Navy's point estimate and GAO's 65 percent confidence level estimate
Planning and design	19.7	30.0	10.3
Dredging	32.3	46.3	14.0
Construction			
Parking garage	38.5	27.8	-10.7
Road improvements	18.4	15.3	-3.1
Wharf F improvements	58.2	38.9	-19.3
Controlled industrial facility	70.5	139.1	68.3
Ship maintenance support facilities	45.6	157.2	111.6
Initial equipment outfitting	48.4	73.0	24.6
Permanent change of station for crew	5.5	10.0	4.5

Source: GAO analysis.

Notes: The low cost estimate is at the 10 percent confidence level and the high cost estimate is at the 90 percent confidence level. It is not statistically appropriate to add each of the individual confidence intervals to come up with an overall confidence interval. In addition to the road improvements on Naval Station Mayport, information provided by a Department of Transportation official indicates that the Jacksonville Transportation Authority, based on its study of traffic improvements to the intersection approaching the main gate outside of the naval station, has identified up to \$8 million in improvements that are unfunded at this time. The official indicated that these improvements are potentially eligible for federal-aid funds.

Table 3 shows the largest difference between the two point estimates is in the construction of the controlled industrial facility and the ship maintenance support facilities, where the Navy's estimates were

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\$68.3 million and \$111.6 million higher than our 65 percent confidence level estimates, respectively. The Navy's estimate of these costs is based on a detailed engineering study developed by an engineering firm. In contrast, our estimate is based on historical costs observed for analogous facility construction projects at Naval Air Station North Island in San Diego in 1995. These analogous costs are adjusted to account for differences in size, inflation, geographical differences between the two areas, and any identified complexities or requirements unique to the Mayport construction. These factors were not present in the San Diego projects. One known complexity of the Mayport construction projects is that the controlled industrial facility must be built to withstand a storm surge from a category 4 hurricane.<sup>17</sup> Our estimate includes a factor of 10 percent of the total construction cost to account for hurricane-related construction complexities.<sup>18</sup> Other complexity factors included environmental considerations and costs associated with antiterrorism and force protection that were not required for the construction at Naval Station North Island. We included both of these factors in our estimate based on a percentage of total construction cost. Neither GAO nor the Navy has identified any other specific complexity factors that would account for the significant discrepancy between the two estimates.

Additionally, other elements of the Navy's estimate were higher than our own. Specifically, the Navy's estimate of initial equipment outfitting was \$24.6 million higher than ours and the Navy's estimate of the permanent change of station cost for relocating the carrier crew was \$4.5 million higher than ours. Finally, the Navy's planning and design estimate was \$10.3 million higher than ours. Both we and the Navy estimated planning and design as a percentage of the overall construction cost. The \$10.3 million difference between the Navy's estimate and ours results from the Navy's higher estimates for construction of the parking garage and controlled industrial facility and ship maintenance support buildings. Appendix II includes our complete cost estimate and explains in more detail our cost estimating results for each element of the one-time costs.

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<sup>17</sup> The Saffir-Simpson Hurricane Wind Scale is a 1 to 5 categorization based on the hurricane's intensity at the given time. A category 4 hurricane has sustained winds of 131 to 155 miles per hour.

<sup>18</sup> This 10 percent factor is based on the best available cost factor information we could identify. Specifically, we use a published study analyzing the effect of changes to existing residential structural vulnerability on hurricane-induced building damage and expected insurance losses. See Stewart et al., *Hurricane Risks and Economic Viability of Strengthened Construction*, *Natural Hazards Review* (February 2003).

GAO Estimates Recurring Costs to Be Between \$9.0 and \$17.6 Million Per Year, and the Navy’s Estimate Falls Within This Range

Our independent cost estimate indicates that the annual recurring cost of homeporting a nuclear-powered aircraft carrier at Naval Station Mayport is expected to be between \$9.0 million and \$17.6 million each year, and the Navy’s \$15.3 million per year estimate of the annual recurring cost is within the range of our estimate. Because the Navy did not conduct a risk and uncertainty analysis on its recurring costs, its estimate does not include a range.

Table 4 shows a comparison between our estimated range and the Navy’s estimate for recurring costs. Specifically, the table shows our estimate range at an 80 percent confidence interval and whether the Navy’s estimate falls into that range. The low value of the estimated range (\$9.0 million) represents a 10 percent chance that the cost will be that amount or less, and the high value of the estimated range (\$17.6 million) represents a 90 percent chance that the cost will be that amount or less. The last column in the table identifies whether the Navy’s estimate is within our estimated range.

Table 4: Comparison of GAO Estimated Range and Navy Point Estimates of Recurring Costs (in Base Year 2010 Dollars)

(Dollars in millions)

Cost element	GAO’s estimated low cost	GAO’s estimated high cost	Navy’s point estimate	Within GAO’s estimated range
Permanently assigned labor for nuclear facilities	0.7	1.9	1.2	Yes
Base operating support	0.7	1.4	1.0	Yes
Facilities sustainment	0.7	1.2	0.8	Yes
Facilities restoration and modernization	2.2	3.3	6.8	No
Operations	0.5	1.4	0.8	Yes
Travel/per diem for public shipyard workers	4.8	12.2	7.0	Yes
Biennial maintenance dredging	0.1	0.2	0.1	Yes
Basic allowance for housing differential	- 5.5	- 4.4	- 3.2	No
Utilities	0.6	1.8	0.8	Yes
Permanent change of station	1.0	1.3	0	No
Private sector travel	0.1	1.2	0	No

Source: GAO analysis.

Notes: The low cost estimate is at the 10 percent confidence level and the high cost estimate is at the 90 percent confidence level. The range and estimate for the basic allowance for housing is negative because the housing allowance is less in the Jacksonville, Florida metropolitan area than it is in Norfolk, Virginia. This results in a net cost savings for the Navy for this cost element. It is not statistically appropriate to add each of the individual confidence intervals to come up with an overall confidence interval. The overall 65 percent confidence level that is reported in app. II is calculated separately from the individual elements.

As we did with one time costs, we also compared our 65 percent confidence level estimates with the Navy's point estimates for a direct element-by-element comparison between our estimate and the Navy's, as shown in table 5.

**Table 5: Comparison of GAO's 65 Percent Confidence Level Estimates and Navy's Point Estimates of Recurring Costs (in Base Year 2010 Dollars)**

(Dollars in millions)

Cost element	GAO's 65 percent confidence level estimate	Navy's point estimate	Difference between Navy's point estimate and GAO's 65 percent confidence level estimate
Permanently assigned labor for nuclear facilities	1.4	1.2	-0.2
Base operating support	1.1	1.0	-0.1
Facilities sustainment	1.0	0.8	-0.2
Facilities restoration and modernization	2.9	6.8	3.9
Operations	1.0	0.8	-0.2
Travel/per diem for public shipyard workers	9.1	7.0	-2.1
Biennial maintenance dredging	0.1	0.1	0
Basic allowance for housing differential	- 4.8	- 3.2	1.6
Utilities	1.3	0.8	-0.5
Permanent change of station	1.2	0	-1.2
Private sector travel	0.6	0	-0.6

Source: GAO analysis.

Note: The estimate for the basic allowance for housing is negative because the housing allowance is less in the Jacksonville, Florida metropolitan area than it is in Norfolk, Virginia. This results in a net cost savings for the Navy for this cost element. It is not statistically appropriate to add each of the individual confidence intervals to come up with an overall confidence interval. The overall 65 percent confidence level that is reported in app. II is calculated separately from the individual elements.

The largest difference between the two estimates is in the cost of facilities restoration and modernization, where the Navy's estimate is \$3.9 million higher. Since the Navy determined this cost as a percentage of total building construction costs for their estimates, the Navy's higher cost results from its higher estimate for construction of the controlled industrial facility and the ship maintenance support buildings. Some of the recurring cost elements, such as the permanently assigned labor for nuclear facilities and base operating support, are slightly higher in our estimate than the Navy's estimate. For these cost elements we used the Navy's estimated costs because we did not have access to a source of information from which we could estimate the costs independently from the Navy. Although we used the same estimate as the Navy, our numbers

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at the 65 percent confidence level are slightly higher than the Navy's because they are risk-adjusted, whereas the Navy's point estimates have not been adjusted for risk. In using the Navy's calculations, we reviewed the Navy's ground rules and assumptions to the extent possible based on the information that the Navy provided to us.

In addition, we included two additional recurring costs in our estimate that were not included in the Navy's estimate—the additional travel costs that the private sector may incur if they have to bring in workers from outside of the Mayport area and the permanent change of station for the aircraft carrier crew during the 10.5-month docking maintenance availabilities and the 3-year midlife refueling overhaul.<sup>19</sup> The recurring costs have been annualized over the 50-year carrier life cycle. Consistent with the Navy's estimate, we have not identified the recurring costs as beginning in any particular fiscal year. Appendix II provides our complete cost estimate and explains in greater detail our cost estimating results for each element of recurring costs. It also contains additional information on the differences between GAO's and the Navy's estimates.

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## Navy's Estimate Does Not Fully Meet Any of the Four Characteristics for Producing a High-Quality Cost Estimate

The Navy's estimate did not fully meet any of the four characteristics—comprehensive, accurate, well documented, and credible—for producing a high-quality cost estimate. Specifically, the Navy's estimate partially met the criteria for being comprehensive; however, the estimate was minimally accurate and well documented and overall, did not meet the criteria for being credible.

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### The Navy's Estimate Is Partially Comprehensive

The Navy's estimate partially meets the criteria for being comprehensive. Specifically, it includes almost all of the life-cycle costs related to

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<sup>19</sup> To facilitate planning for aircraft carrier maintenance, the Navy has developed a general model of maintenance that spans the 50 years an aircraft carrier is expected to be in the active inventory. Within this 50 years are scheduled aircraft carrier maintenance periods known as availabilities. There are four types of maintenance availabilities: carrier incremental availability lasting approximately 1 month; planned incremental availability lasting approximately 6 months; docking planned incremental availability lasting about 10.5 months; and a midlife refueling complex overhaul lasting about 39 months.

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homeporting a nuclear-powered aircraft carrier at Naval Station Mayport. The Navy did not include two small recurring costs: (1) the additional travel costs that the private sector may incur if they have to bring in workers from outside of the Mayport area and (2) the permanent change of station for the carrier crew during the 10.5-month docking planned incremental availability and 39-month midlife refueling overhaul. However, the estimate does not fully document the cost-influencing ground rules and assumptions. Additionally, the Navy only minimally provided a cost element breakdown structure in its estimate, and in conducting our assessment, we had to develop our own more robust structure to ensure that cost elements were neither omitted nor double counted. Individual segments of the Navy's cost estimate were completed by separate Navy teams and then pieced together into two documents that represent the Navy's cost estimate. According to Navy officials, there was no single person or team in charge of ensuring that the entire Mayport homeporting estimate was packaged into a comprehensive and well documented final estimate.

According to GAO's guide, a cost estimate is comprehensive when it includes both government and contractor costs of the program over its full life cycle, from inception of the program through design, development, deployment, and operation and maintenance to retirement of the program. It should also completely define the program, reflect the current schedule, and be technically reasonable. Comprehensive cost estimates should be structured in sufficient detail to ensure that cost elements are neither omitted nor double counted. Specifically, the GAO guide states that the cost estimate should be based on a product-oriented work breakdown structure that allows a program to track cost and schedule by defined deliverables, such as hardware or software components. Finally, where information is limited and judgments must be made, the cost estimate should document all cost-influencing ground rules and assumptions. Appendix III provides our assessment of the extent to which the Navy's estimate met the best practices for the four characteristics of a high-quality cost estimate—comprehensive, well documented, accurate, and credible—described in the *GAO Cost Estimating and Assessment Guide*.

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## The Navy's Estimate Is Minimally Accurate

The Navy's estimate is minimally accurate. Some elements of the estimate are based on a historical record of cost estimating and actual experiences from other comparable programs. Many of the recurring costs—such as the facilities sustainment, operations, and the biennial dredging costs—are based on a historical record of past costs. However, no evidence was provided by the Navy to show that a risk and uncertainty analysis was

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conducted. Therefore, the confidence level of the estimate can not be determined, and it is difficult to say if the cost estimates are the most likely costs. In addition, the initial cost estimate provided to us by the Navy contained calculation errors, although the Navy identified the errors after discussions with GAO and corrected the errors in subsequent versions of its estimate.

An estimate is considered accurate when it is based on an assessment of the costs most likely to be incurred, according to GAO's cost estimating guide. The results should be unbiased, that is not overly conservative or optimistic. Additionally, the estimate should be based on a historical record of cost estimating and actual experiences from other comparable programs. The Navy based its estimate of construction costs on a detailed engineering estimate produced by a private architecture and engineering firm, but prior to GAO's review, the Navy had not reviewed the firm's engineering estimate to verify the accuracy and completeness of the estimate and did not check whether the engineering estimate relied on overly conservative assumptions or fell within the range of historical costs. Without ensuring that its military construction estimates are accurate, the Navy may be overestimating the costs of new construction at Mayport, which could result in the Navy requesting more funding than is needed and limit the amount of money available to fund other projects.

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### The Navy's Estimate Is Minimally Well Documented

Although the Navy's documentation contains some discussion of the technical information used in the estimate, the Navy's estimate is minimally well documented. The documentation contains very little step-by-step description of how the estimate was developed so that a cost analyst unfamiliar with the program could understand what was done and replicate it. Additionally, the documentation does not capture the source data used, the reliability of the data, and how the data were standardized. Moreover, Navy officials had to recreate several portions of the estimate to provide us with supporting documentation.

Cost estimates, according to GAO's cost estimating and assessment guide, are well documented when they can be easily repeated or updated and can be traced to original sources. The documentation should explicitly identify the primary methods, calculations, assumptions, and sources of the data used to generate each cost element. The estimating process should be described and an explanation provided for why particular methods and data sets were chosen and why these choices are reasonable. All the steps involved in developing the estimate should be documented so that a cost analyst unfamiliar with the program could recreate it with the same result.

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In addition, documentation for the cost estimate should reflect changes in technical or program assumptions or new program phases or milestones. Insufficient documentation makes it difficult for outside organizations to validate the Navy's life-cycle cost estimate for homeporting an aircraft carrier at Naval Station Mayport. Not having adequate documentation also impedes the Navy's ability to develop future estimates and facilitate oversight by Congress.

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### The Navy's Estimate Does Not Meet GAO's Best Practices for a Credible Estimate

Overall, the Navy's estimate does not meet the GAO best practices' criteria for a credible estimate, because it does not include a sensitivity analysis and was not compared by the Navy to an independent cost estimate conducted by a group outside the acquiring organization. Although DOD's Office of Cost Assessment and Program Evaluation did review the Navy's presentations and supporting documentation in conjunction with the 2010 Quadrennial Defense Review working group, the office only performed a general review of the Navy's costs, not a full independent cost estimate with a sensitivity analysis. Further, while the Navy did identify some risks, it did not conduct a formal risk and uncertainty analysis that would identify a level of confidence in the estimate. In addition, although some cost elements in the Navy's estimate were derived from models that have undergone validation, verification, and accreditation, others were not. For example, the model that was used to develop the estimate of the recurring travel cost for the maintenance workers who would travel from Norfolk Naval Shipyard to work on the carrier's nuclear propulsion systems in Mayport underwent a documented validation, verification, and accreditation process. Similarly, the DOD's facilities sustainment model that was used to calculate the recurring facilities sustainment costs was also validated, verified, and accredited. However, we did not find any evidence that any validated, verified, or accredited model was used for calculating the costs of transporting equipment for the carrier air wing, the cost of the differential in the basic allowance for housing between Norfolk and Mayport, the cost of the differential in utilities charges between Norfolk and Mayport, or the cost of the permanent change of station for the aircraft carrier crew. In terms of risk analysis, only the military construction estimates contained any consideration of risk, in the form of contingency factors.

Moreover, we found that the Navy has not assigned a single office with the responsibility for ensuring that the overall estimate for Mayport homeporting was packaged into a comprehensive and well documented final estimate and that a sensitivity analysis was conducted on the estimate to determine which cost elements, and which factors of those



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cost elements, most influenced the overall cost. When an organization does not assign a single office responsibility for assembling the estimate into a comprehensive package, it is difficult to conduct proper sensitivity and risk analyses. Additionally, different offices preparing parts of the estimate may use conflicting assumptions. For example, different offices may use different assumptions regarding the treatment of inflation. Some costs may be expressed in base year dollars, while others are expressed in then-year dollars. This was the case with the Navy's original estimates which showed one-time costs in then-year dollars and recurring costs in base year 2010 dollars. Even if amounts are all expressed using the same type of dollars, different contributors may use different inflation indexes, resulting in conflicting underlying assumptions.

According to GAO's guide, cost estimates are credible when

- major assumptions have been varied and other outcomes recomputed to determine how sensitive outcomes are to changes in the assumptions,
- risk and uncertainty analyses have been performed to determine the level of risk associated with the estimate, and
- the estimate's results have been cross-checked and an independent cost estimate has been developed to determine whether other estimating methods produce similar results.

Sensitivity and risk analyses should be included in all cost estimates as a best practice because all estimates have some uncertainty. A sensitivity analysis addresses some of the estimating uncertainty by testing discrete cases of assumptions and other factors that could change. By examining each assumption or factor independently, while holding all others constant, the cost estimator can evaluate the results to discover which assumptions or factors most influence the estimate. However, because many parameters could change at the same time, a risk analysis should also be performed to capture the cumulative effect of additional risks. Risk analysis adds to the credibility of a cost estimate because it quantifies the uncertainty and provides a level of confidence associated with the point estimate. The results of a high-quality, reliable cost estimate should also be cross-checked, and an independent cost estimate should be developed to determine whether other estimating methods produce similar results. An independent cost estimate is considered to be one of the most reliable validation methods and is typically performed by organizations higher in the decision-making process, or entirely outside of the office performing the baseline cost estimate, using different estimating techniques and,

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where possible, different data sources from those used to develop the baseline cost estimate.

Performing a sensitivity analysis for the Mayport aircraft carrier estimate would help to identify and focus on key elements with the greatest effects on cost and understand the potential for cost growth and the reasons for it. Additionally, because the Navy has not conducted a risk and uncertainty analysis, it is unable to provide Congress with a reasonably high confidence level for its Mayport aircraft carrier cost estimate. Performing a risk and uncertainty analysis would enable the Navy to quantify the risk and uncertainty associated with the cost model; provide a level of confidence for its cost estimate; and give decision makers perspective on the potential variability of the cost estimate should facts, circumstances, and assumptions change.

Navy officials told us that short time frames and budgetary constraints prevented them from following the criteria for comprehensiveness, accuracy, documentation, and credibility in developing their estimate. For elements of the recurring costs, such as the travel and per diem for public shipyard workers, the estimates were produced in response to different congressional requests for information often requiring quick turnaround—in some cases as short as 3 days. Navy officials told us that in the case of the military construction estimates, their intention was not to develop budget quality estimates, but rather an estimate more suitable for initial programming and planning purposes. Navy officials noted that this is a typical approach for construction projects that are not scheduled to begin for several years. According to the Navy, it would have been cost prohibitive to develop budget quality estimates for every proposed military construction project. Navy officials stated that the Navy further reviews and refines the construction estimates as they proceed through the DOD budget process. Because many of the projects planned for Mayport would be included in future budgets, these projects have not yet undergone this review. Consistent with prior experience, it may not have been feasible for the Navy to follow cost estimating best practices to the fullest extent in developing initial estimates, especially given the short time frames often available. However, as the Navy continues to respond to congressional interest in the costs associated with homeporting a nuclear carrier at Mayport, it has the opportunity to more completely incorporate cost estimating best practices in its revised estimate, thereby improving the estimate's quality and making it easier to defend in future budgets and decision making.

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## Conclusions

The Navy's ability to produce a comprehensive, accurate, well documented, and credible cost estimate for homeporting a nuclear-powered aircraft carrier at Naval Station Mayport will continue to be hampered until it makes certain fundamental changes to the process it uses to develop, document, and update its overall estimate of Mayport homeporting costs. Specifically, without full documentation of the data sources, assumptions, and calculation methods it uses, the Navy cannot assure that its estimate can be validated or defended or any differences between estimated and actual costs can be explained—an important step in improving and updating the estimate. Additionally, without detailed documentation that describes how the estimate was derived, the Navy can neither present a convincing argument of the estimate's affordability, nor credibly answer decision makers' and oversight groups' questions about specific details in the estimate. Further, without conducting sensitivity and risk and uncertainty analyses on its cost estimate, the Navy is unable to identify and focus on major cost drivers, analyze the potential for cost growth, and quantify the risk and uncertainty associated with the cost estimate. Moreover, without a comprehensive, accurate, well documented, and credible cost estimate, Congress cannot have reasonable confidence that it has a complete understanding and an accurate and realistic determination of the projected costs to evaluate and make decisions on the Navy's planned homeporting of a nuclear-powered aircraft carrier at Mayport.

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## Recommendations for Executive Action

To improve the Navy's life-cycle cost estimate for the planned homeporting of a nuclear-powered aircraft carrier at Naval Station Mayport, Florida, we recommend that the Secretary of Defense direct the Secretary of the Navy to take the following three actions to incorporate to a greater extent the best practices identified by GAO for developing a high-quality cost estimate in future revisions of its Mayport nuclear carrier homeporting cost estimate as part of the annual budgetary process or in response to future congressional requests:

1. To improve the comprehensiveness of its cost estimate, the Navy should
  - include all potential recurring costs, and
  - clearly describe the ground rules and assumptions underlying the estimation of each cost element;
2. To improve the quality and transparency of the Navy's estimate, the Navy should thoroughly document the life-cycle costs associated with homeporting a nuclear-powered aircraft carrier at Naval Station Mayport. Specifically, documentation should

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- identify the source data used, their reliability, and how the data were normalized,
  - describe the steps used in developing the overall estimate so that it can be clearly understood and easily replicated, and
  - describe in sufficient detail the estimating methodology and calculations performed to derive each element's cost; and
3. To improve the accuracy and credibility of its cost estimate, the Navy should assign a single office with the responsibility for assembling the overall estimate into a comprehensive and well documented package and for performing a sensitivity and risk and uncertainty analyses on the overall estimate to identify the
- major cost drivers,
  - extent to which estimates could vary due to changes in key cost assumptions, and
  - level of confidence in the estimate.
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## Agency Comments and Our Evaluation

In written comments on a draft of this report, DOD partially concurred with two and nonconcurred with one of our three recommended actions. DOD also provided technical comments that we have incorporated into this report where applicable. DOD's written comments are reprinted in appendix IV.

DOD partially concurred with our two recommendations that the Secretary of Defense direct the Secretary of the Navy to improve the (1) comprehensiveness of the Navy's life-cycle cost estimate for the planned homeporting of a nuclear-powered aircraft carrier at Naval Station Mayport by including all potential recurring costs and clearly describing the ground rules and assumptions underlying the estimation of each cost element and (2) quality and transparency of the Navy's estimate by thoroughly documenting the life-cycle costs associated with the planned homeporting. DOD stated that the elements, or cost estimating best practices, cited in our recommendations may contribute to improved quality in cost estimates, but they may not be ideally suited to the myriad situations in which the Navy is required, or may be requested, to provide cost estimates to Congress.

We recognize that it may not have been feasible for the Navy to always follow cost estimating best practices to the fullest extent in developing some of its initial estimates, especially when the preparation time for some estimates may have been limited. However, both recommendations were directed at improving future Navy cost estimates associated with the Mayport carrier homeporting. As the Navy continues to respond to

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congressional interest, we believe it has the opportunity to more completely incorporate the cost estimating best practices we identified in our report in its revised estimates for Mayport in order to improve the quality of its estimates. Additionally, DOD states that the similarity between our initial estimate and the Navy's budget estimate for dredging costs suggests that the Navy's programming/budgeting process leads to high-quality, credible cost estimates. However, the Navy's overall Mayport estimate currently includes several cost elements that have not been refined through a programming/budgeting process. Furthermore, as described in our report, GAO's criteria for assessing high-quality, credible estimates involve factors that go beyond the accuracy of any individual point estimate. The convergence between our estimate and the Navy's estimate on a single cost element is not an indication by itself of the quality of the Navy's overall estimate for homeporting a nuclear carrier at Mayport. Improving the Mayport estimate's quality will allow the Navy to more easily defend its plans in future decisionmaking and budgets within DOD. We believe that in order to best inform the budget decisionmaking process of the likely costs, affordability, and scheduling of funding needed to support the Navy's plans for Mayport, DOD should take every available opportunity to provide Congress with the highest quality cost estimates possible. We therefore believe these two recommendations remain valid.

DOD disagreed with our third recommendation that the Secretary of Defense direct the Secretary of the Navy to improve the accuracy and credibility of its cost estimate by assigning a single office with the responsibility for assembling the overall estimate into a comprehensive and well documented package and for performing sensitivity and risk and uncertainty analyses on the overall estimate. DOD stated that responsibilities for centralized supervision and coordination of programming and budgeting within the Department of the Navy are well-established and that Navy program/budget estimates and exhibits are prepared and submitted in accordance with the Office of the Secretary of Defense guidance. DOD further noted that reports to Congress are typically assigned to a central office for preparation and coordination and that where necessary, instructions to the offices providing inputs can include guidance on baseline assumptions.

As we state in our report, the Navy's level of coordination used in packaging its final cost estimate did not ensure that the offices providing inputs adequately and completely documented the cost estimates and did not provide for the implementation of sensitivity and risk and uncertainty analyses. Additionally, the Navy's final cost estimate was not consistent in its use of various baseline assumptions, such as consistency in using either

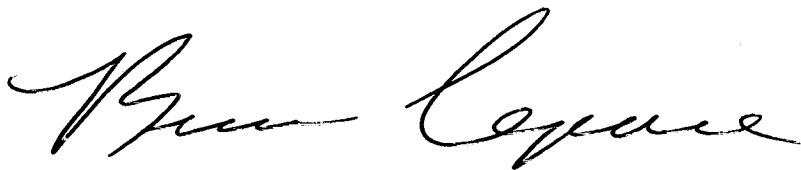
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then-year or constant dollars in the individual original estimates that made up the Navy's final estimate for Mayport. This lack of consistency limits the Navy's ability to appropriately combine the estimates from different offices into a single, coherent cost estimate. High-quality cost estimating requires good organization and a consistent approach in pulling together disparate data for each cost element and packaging it as an accurate and credible whole. Thus, without a single office—within the already established programming/budgeting process—that is responsible for assembling future revisions of its Mayport estimate, the Navy will continue to lack assurance that its overall estimate is comprehensive, well documented, accurate, and credible. We therefore believe this recommendation remains valid.

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We are sending copies of this report to interested congressional committees, the Secretary of Defense, the Secretary of the Navy, and the Director, Office of Management and Budget. The report is also available at no charge on the GAO Web site at <http://www.gao.gov>.

If you or your staff have any questions concerning this report, please contact me at (202) 512-4523 or [leporeb@gao.gov](mailto:leporeb@gao.gov). Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. Key contributors to this report are listed in appendix V.

A handwritten signature in black ink, appearing to read "Brian Lepore". The signature is fluid and cursive, with the first name "Brian" and last name "Lepore" clearly distinguishable.

Brian J. Lepore  
Director, Defense Capabilities and Management

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*List of Committees*

The Honorable Carl Levin  
Chairman  
The Honorable John McCain  
Ranking Member  
Committee on Armed Services  
United States Senate

The Honorable Daniel K. Inouye  
Chairman  
The Honorable Thad Cochran  
Ranking Member  
Subcommittee on Defense  
Committee on Appropriations  
United States Senate

The Honorable Howard P. McKeon  
Chairman  
The Honorable Adam Smith  
Ranking Member  
Committee on Armed Services  
House of Representatives

The Honorable C.W. Bill Young  
Chairman  
The Honorable Norman D. Dicks  
Ranking Member  
Subcommittee on Defense  
Committee on Appropriations  
House of Representatives

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# Appendix I: Scope and Methodology

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To develop an independent cost estimate of the full life-cycle costs associated with the Navy's plan to establish a second East Coast homeport for a nuclear-powered aircraft carrier we worked with a consultant from a cost estimating company—Technomics, Inc.—with expertise in preparing estimates of the full life-cycle costs of major federal programs.<sup>1</sup> We followed the 12 steps for developing a high-quality cost estimate outlined in the *GAO Cost Estimating and Assessment Guide*.<sup>2</sup>

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## Step 1: Define Estimate's Purpose

The purpose of the estimate is to satisfy the direction provided to GAO in House Report 111-491, accompanying a proposed bill for the Fiscal Year 2011 National Defense Authorization Act (H.R. 5136), to develop an independent estimate of the total direct and indirect costs to be incurred by the federal government for the proposed homeporting of a nuclear-powered aircraft carrier at Naval Station Mayport.<sup>3</sup> The estimate will provide the defense committees with an independent cost estimate against which they can evaluate the Navy's estimate and give Congress greater confidence that it has an accurate understanding of the total cost associated with establishing a homeport for a nuclear-powered aircraft carrier at Naval Station Mayport.

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## Step 2: Develop Estimating Plan

Upon identification of the direction in the committee report, we identified resources and developed a design matrix that included identification of information required and sources, and the proposed scope and methodology for addressing the direction. Additionally, in accordance with Generally Accepted Government Auditing Standards (GAGAS), we conducted an entrance conference with the Navy, collected cost data, and conducted interviews with program officials.

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## Step 3: Define Program Characteristics

We collected information directly from the Navy that enabled us to define the program's technical and programmatic baseline. Specifically, the Navy provided us with its estimates of one-time and recurring costs, including any supporting documentation that outlined the underlying assumptions

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<sup>1</sup> Technomics, Inc., Arlington, Virginia.

<sup>2</sup> [GAO-09-3SP](#).

<sup>3</sup> See H.R. Rep. No. 111-491, at 507.



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and ground rules supporting the estimates.<sup>4</sup> We also reviewed the Navy's environmental impact study along with background information about nuclear-powered aircraft carrier maintenance, visited locations where nuclear-powered aircraft carrier maintenance is performed, and spoke with Navy officials knowledgeable about the personnel and facilities requirements for nuclear-powered aircraft carrier maintenance.

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**Step 4: Determine Estimating Structure**

We developed a cost element structure that was derived from the Navy's cost estimate and supporting documentation. Where necessary, we added subelements or additional elements. At the highest level of our estimate, costs were categorized by one-time costs (1.0 elements) and recurring costs (2.0 elements). For each cost element, the most appropriate estimating approach was identified according to data availability and credibility. Estimating approaches applied included analogy, expert opinion, and parametric methods.

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**Step 5: Identify Ground Rules and Assumptions**

Estimating ground rules and assumptions were identified and documented. Assumptions were minimized, relying instead on real data when possible. In order to develop an independent estimate, we generally used methods and data that differed from the Navy's, relying instead on two types of estimating methods: scaled analogy and parametric. Scaled analogy is a cost estimating method that relies on using actual costs from analogous projects. Adjustments to cost were made for the relative size of the analogous project as well as appropriate adjustments for complexity factors. A parametric estimate is a method that uses an established relationship between cost and one or more input variables. The input variables become parameters in an equation that is used to predict cost. It is important to note, however, that the Navy was the only source of information for certain cost subelements, such as the number of man-days of maintenance required for aircraft carrier availabilities and the cost of transporting equipment for the carrier air wing and this limited the degree to which our cost estimate is completely independent from the Navy's for those elements.

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<sup>4</sup> There were some instances in which the Navy did not have any supporting documentation for its assumptions.

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**Step 6: Obtain Data**

Cost, technical, and programmatic data were solicited and collected through interviews and supporting documentation. Interviews were conducted with and supporting documentation was obtained from officials in the Office of the Chief of Naval Operations, Naval Sea Systems Command, Regional Maintenance Centers, as well as officials from Norfolk Naval Shipyard, Naval Station Mayport, and Naval Air Station North Island. Specific documents and data we collected included Navy responses to information requests, programming models, and construction planning documents. Additionally, we collected and reviewed data on unrelated but analogous Navy and DOD construction projects. In addition, we analyzed the uncertainty associated with our estimates to help gauge their accuracy. We assessed the reliability of all data provided by the Navy by (1) reviewing existing information about the data and the systems that produced them, (2) interviewing agency officials knowledgeable about the data to determine the steps taken to ensure the accuracy and completeness of the data, and (3) reviewing the related internal controls. Based on this assessment, we determined the data were sufficiently reliable for our purposes.

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**Step 7: Develop Point Estimate<sup>5</sup>**

Data collected were thoroughly analyzed, resulting in the development of several different cost estimating methodologies. These methodologies were integrated into a comprehensive cost model using Microsoft ® Excel, resulting in a detailed point estimate.

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**Step 8: Conduct Sensitivity Analysis**

A comprehensive sensitivity analysis was conducted on the cost model also using Microsoft ® Excel. Sensitivity analysis addresses the question of which cost model inputs have the greatest impact on the overall cost estimate. Inputs that have the greatest impact are often referred to as cost drivers. Our sensitivity analysis identified all of the inputs used in each cost element. Each input was changed, in isolation, to determine the impact on the bottom line cost. Some inputs, such as geographic adjustment factors, have an impact on multiple elements. Other inputs only impact a specific cost element.

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<sup>5</sup> Although the *GAO Cost Estimating and Assessment Guide* lists step 7 as “develop the point estimate and compare it to an independent estimate”, our objectives led us to develop an independent estimate for comparison to the Navy’s estimate. We therefore list step 7 as simply “develop the point estimate.”

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**Step 9: Conduct Risk and Uncertainty Analysis**

Risk and uncertainty analysis was conducted in order to transform the static point estimate into a probabilistic range based on the risk and uncertainty inherent in the model input variables. Within the risk analysis section of our estimate, each cost input and each cost estimating method was assigned a low and high value based on the relative uncertainty associated with each value. Inputs that had little or no uncertainty (such as actual costs, or known square footages) had a small, or possibly a zero range between the high and low values. In contrast, variables with a high level of uncertainty had a wider range. We then assigned a triangular probability distribution to each element, defined as either a low value, a most likely value (the point estimate), or a high value. Using a Monte Carlo simulation, the risk analysis was then assigned a random value, according to the probability distribution of each variable. Total cost was then calculated and the process was repeated to obtain a range of possible total cost outcomes. The simulation resulted in establishing probability distributions about the estimated values, enabling the identification of the confidence level of the point estimate.

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**Step 10: Document the Estimate**

Detailed documentation was generated that provides the cost estimate results, as well as ground rules and assumptions, and all underlying cost estimating methodology. The cost model was thoroughly referenced to source documents and then traced and verified in accordance with generally accepted government auditing standards.

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**Step 11: Present Estimate to Management for Approval**

The resulting cost estimates were presented to various levels of GAO management. Additionally, GAO presented the cost estimate and underlying methodology in detail to the Navy in January 2011.

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**Step 12: Update the Estimate to Reflect Actual Costs and Changes**

Upon presenting the cost estimate and underlying methodology in detail to Navy, the Navy provided comments, questions, and some additional data which we incorporated as appropriate in our estimate.

Within each cost element, we compared our estimate to the Navy's. Wherever possible, the reasons for significant differences were discussed with the Navy and explained in the report. Our estimate does not estimate or evaluate any of the benefits of a potential homeport move, and therefore does not address or evaluate the military advantages or disadvantages associated with the homeporting decision. Additionally, our estimate only includes estimated costs incurred by the Navy and it does

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not include any estimate of the economic impact to the local economy in Virginia or Florida.

To determine to what extent the estimate adheres to the characteristics of a high-quality cost estimate, we evaluated the Navy's life-cycle cost estimate to determine whether it met key characteristics identified in the *GAO Cost Estimating and Assessment Guide*. Our guide, which is based on extensive research of best practices for estimating program schedules and costs, indicates that a high-quality, valid, and reliable cost estimate should be well documented, comprehensive, accurate, and credible. We analyzed the cost estimating practices used by the Navy against these best practices. Specifically, to determine whether the Navy's estimate was well documented, we examined whether the Navy estimate's documentation explicitly identified the primary methods, calculations, results, rationales or assumptions, and sources of data used to generate each cost element. To determine whether the estimate was comprehensive, we examined whether the Navy's cost estimate included all life-cycle costs required to homeport a nuclear aircraft carrier at Naval Station Mayport. To determine whether the Navy's estimate was accurate, we verified the calculations in the Navy's estimate and examined whether the estimate accounted for all costs, including indirect costs. Finally, to determine whether the Navy's estimate was credible, we examined the extent to which the Navy tested key cost elements for sensitivity or used other cost estimating techniques to cross-check the reasonableness of their ground rules and assumptions. We also interviewed Navy officials from the Naval Sea Systems Command and the Office of the Chief of Staff of Naval Operations about the process used to prepare the life-cycle cost estimates and the assumptions used to prepare the Navy's estimate. We shared the *GAO Cost Estimating and Assessment Guide* and the criteria against which we would be evaluating the Navy's cost estimate with the Navy.

We conducted our performance audit from July 2010 through February 2011 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

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# Appendix II: Additional Information on GAO's Independent Cost Estimate

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## **Nuclear-Powered Aircraft Carrier Homeporting Costs at Naval Station Mayport, Florida**

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**GAO's Independent Cost Estimate**

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## Contents

- Purpose of the Estimate
- Program Characteristics
- Estimating Structure
- Ground Rules and Assumptions
- Methodology
- Overview
- Comparison of GAO's 65 Percent Confidence Level Estimates and Navy's Point Estimates
- Risk-adjusted Ranges
- Individual Cost Elements



## Purpose of the Estimate

- Satisfy the direction in House Report 111-491, accompanying a proposed bill for the Fiscal Year 2011 National Defense Authorization Act (H.R. 5136), to develop an independent estimate of the total direct and indirect costs to be incurred by the federal government for the proposed homeporting of a nuclear-powered aircraft carrier at Naval Station Mayport.
- Provide the congressional defense committees with an independent cost estimate against which they can evaluate the Navy's estimate and give Congress greater confidence that it has an accurate understanding of the total cost associated with establishing a homeport for a nuclear-powered aircraft carrier at Naval Station Mayport, Florida.



## Program Characteristics

- The controlled industrial facility and ship maintenance support facilities in Mayport have been modeled on the facilities built at Naval Air Station North Island, San Diego, California in the late 1990s to support the first nuclear-powered aircraft carriers to be homeported in San Diego.
- Nuclear-powered aircraft carrier maintenance is performed on a 32-month cycle that includes two 1-month long Carrier Incremental Availabilities and either one 6-month Planned Incremental Availability or a 10.5-month Docking Planned Incremental Availability. There is also one refueling complex overhaul around the carrier's midlife that lasts about 39 months.
- The Carrier Incremental Availabilities and Planned Incremental Availabilities will be performed in Mayport, while the Docking Planned Incremental Availabilities will be performed at Norfolk Naval Shipyard.





## Estimating Structure

- The cost element structure used in this estimate was derived from the Navy's cost estimate and associated documentation. Where necessary, we have added subelements or additional elements. At the highest level, costs are categorized by one-time costs (1.0 elements) and recurring costs (2.0 elements).



## Estimating Structure

1.0 One-time costs	2.0 Recurring Costs
1.1 Planning and Design	2.1 Permanently Assigned Labor for Nuclear Facilities
1.2 Dredging	2.2 Base Operating Support for New Facilities
1.3 Construction	2.2.1 Entry Control Point Sentries
1.3.1 Parking	2.2.2 Facilities Planning, Facilities Services, and Transportation
1.3.2 Road Improvements	2.3 Facilities Sustainment
1.3.3 Wharf F Improvements	2.4 Facilities Restoration and Modernization
1.3.4 Controlled Industrial Facility (CIF)	2.5 Operations
1.3.5 Ship Maintenance Facility (SMF)	2.6 Travel / Per Diem for Government Maintenance Workers, Annualized
1.3.6 Maintenance Support Facility (MSF)	2.6.1 Carrier Incremental Availabilities
1.4 Initial Outfitting	2.6.2 Planned Incremental Availabilities
1.4.1 CIF Equipment	2.6.3 Voyage Repair
1.4.2 SMF Equipment	2.7 Biennial Dredging
1.4.3 MSF Equipment	2.8 Basic Allowance for Housing Differential
1.5 Permanent Change of Station for the Crew	2.9 Utilities
	2.10 Permanent Change of Station for the Crew
	2.10.1 Docking Planned Incremental Availability
	2.10.2 Refueling Complex Overhaul
	2.11 Private Sector Travel

Source: GAO analysis.



## Ground Rules and Assumptions

The following general assumptions apply to all cost elements:

- In order to develop an independent estimate, we generally use methods and data that differ from the methods and data used in the Navy's cost estimate. However, the Navy is likely the only source of information for certain cost subelements such as the number of man-days of maintenance required for aircraft carriers and the cost of transporting equipment for the carrier air wing.
- The time frame for one-time costs will be consistent with the Navy's estimate, which spans from fiscal year 2010 to fiscal year 2019.



## Ground Rules and Assumptions

- The recurring costs have been annualized over the 50-year carrier life cycle. Consistent with the Navy's estimate, we have not identified an exact start date for the recurring costs.
- We estimated the cost differentials associated with moving a nuclear-powered aircraft carrier to Mayport. This means that our estimate only includes costs that differ from what the Navy would spend under the current mode of homeporting all East Coast carriers in Norfolk, Virginia. This assumption is consistent with the Navy's cost estimate.



## Ground Rules and Assumptions

- Both one-time and recurring costs will be reported in base-year 2010 dollars, which have the effects of inflation removed. In calculations where inflation needs to be added or removed, the estimate uses the appropriation-specific cost indexes published annually by the Naval Center for Cost Analysis.
- We do not estimate or evaluate any potential economic impacts that may be experienced by either the Norfolk or Mayport communities from the planned homeporting. As directed in House Report 111-491, accompanying a proposed bill for the Fiscal Year 2011 National Defense Authorization Act (H.R. 5136), our estimate is limited to the costs to be incurred by the federal government in homeporting a nuclear-powered aircraft carrier at Naval Station Mayport.



## Methodology

- The data that we collected were integrated into a comprehensive cost model that we developed using Microsoft® Excel, resulting in cost estimates for each individual cost element, as well as overall cost estimates.
- To develop the cost estimates, we worked with an outside cost estimating company with expertise in preparing estimates of the life-cycle costs of major federal acquisitions.
- We then conducted a sensitivity analysis to determine which of the cost model inputs had the greatest impact on the overall cost element. Those inputs are known as cost drivers.



## Methodology

- Next, we conducted a risk and uncertainty analysis as a way to assess the variability in the point estimate. Risk analysis addresses the uncertainty that is inherent within cost inputs and cost estimating methods. Inputs that have little or no uncertainty (such as sunk costs, or known square footages) will have a small, or possibly a zero range between the high and low values. In contrast, variables with a high level of uncertainty have a wider range.
- The results of the risk analysis can also be viewed as an “S-Curve”, which plots various risk-adjusted cost totals against a cumulative confidence level. The probabilities shown on the Y axis of an S curve represent the probability that costs will be equal to or less than the amount shown on the X axis. For example, to obtain the risk-adjusted cost estimate at which there is a 90 percent probability that the true costs will be equal to or less than the risk-adjusted total, determine the dollar value from the X axis where the S curve crosses 90 percent.



## Overview

- Our independent cost estimate suggests that the one-time cost for establishing a nuclear-powered aircraft carrier homeport at Naval Station Mayport is expected to be between \$258.7 million and \$356.0 million, with a 65 percent confidence level estimate of \$322.0 million. The recurring costs are expected to be between \$9.0 million and \$17.6 million per year, with a 65 percent confidence level estimate of \$14.3 million.
- The Navy's point estimate of \$537.6 million for the one-time cost falls outside the upper range of our estimate, but the Navy's point estimate of \$15.3 million/year for recurring costs does fall within our estimated range. The largest difference between our estimate and the Navy's is in the one-time construction costs for the new controlled industrial facility and ship maintenance support facilities in Mayport.
- The parameters related to the construction of the controlled industrial facility and the ship maintenance support facilities are the cost drivers for the one-time costs, while the parameters related to the travel cost are the cost drivers for the recurring costs.

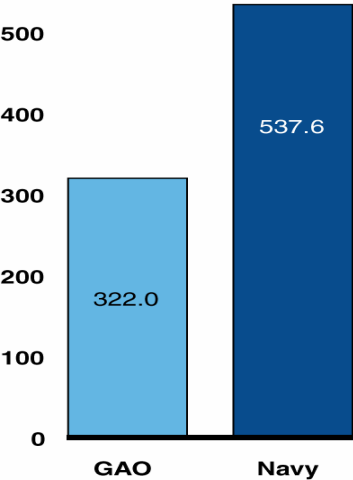




# Total Homeporting Cost

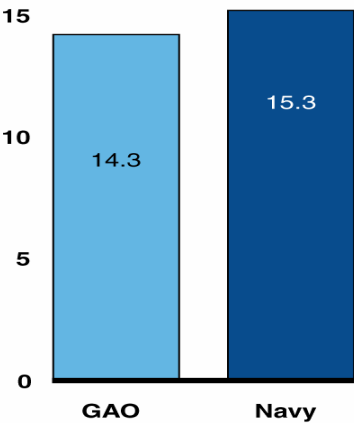
**One-time cost**

Dollars (in millions), base-year 2010



**Recurring costs**

Dollars (in millions), base-year 2010

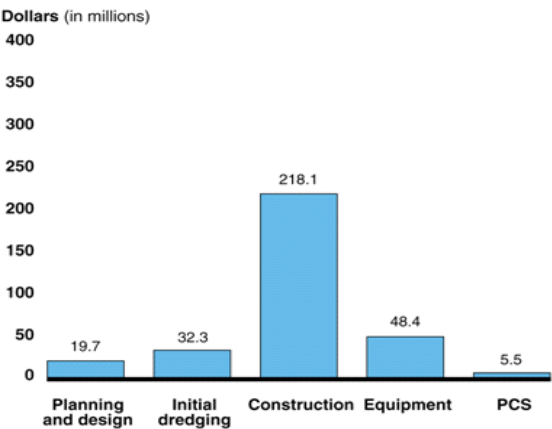


Source: GAO analysis.

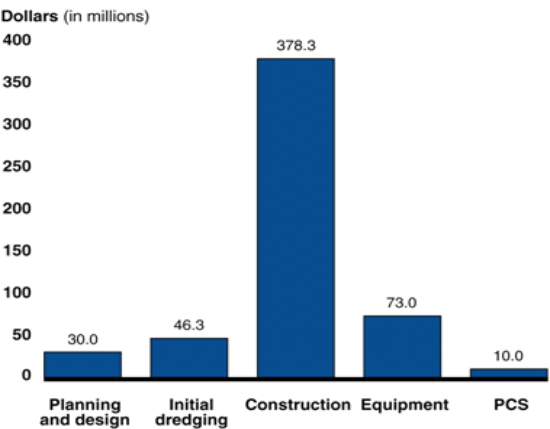


# One-Time Cost

GAO estimate - \$322.0 million



Navy estimate - \$537.6 million



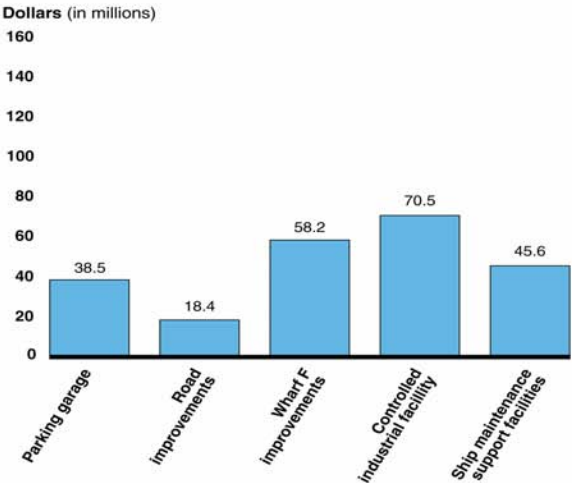
Source: GAO analysis.

It is not statistically appropriate to add each of the individual 65 percent confidence level cost estimates to come up with an overall 65 percent confidence level. The overall 65 percent confidence level is calculated separately from the individual elements.

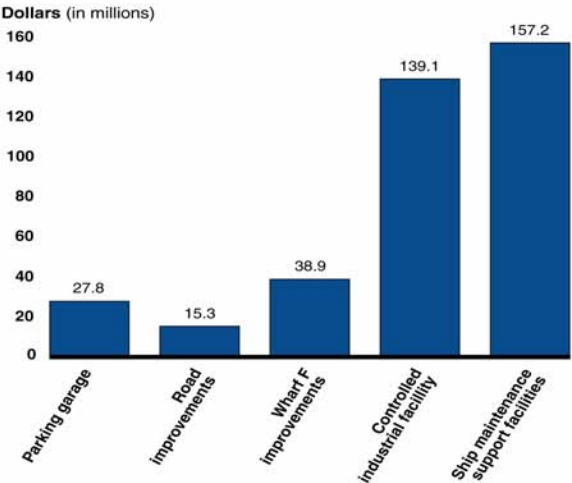


# Construction Cost

GAO estimate - \$218.1 million



Navy estimate - \$378.3 million



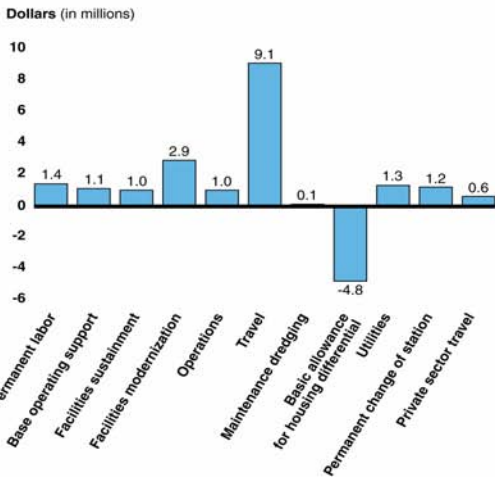
Source: GAO analysis.

It is not statistically appropriate to add each of the individual 65 percent confidence level cost estimates to come up with an overall 65 percent confidence level. The overall 65 percent confidence level is calculated separately from the individual elements.

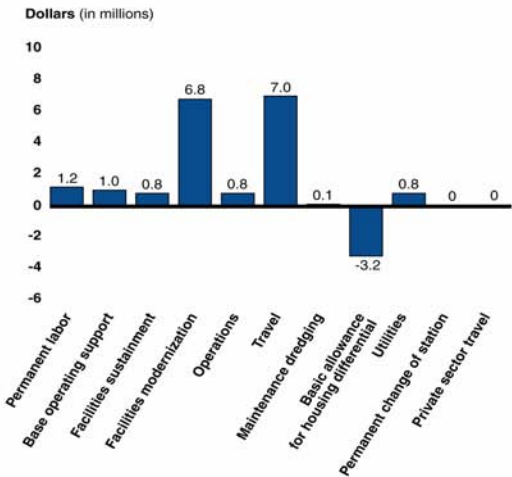


# Recurring Costs

GAO estimate - \$14.3 million



Navy estimate - \$15.3 million



Source: GAO analysis.

It is not statistically appropriate to add each of the individual 65 percent confidence level cost estimates to come up with an overall 65 percent confidence level. The overall 65 percent confidence level is calculated separately from the individual elements.

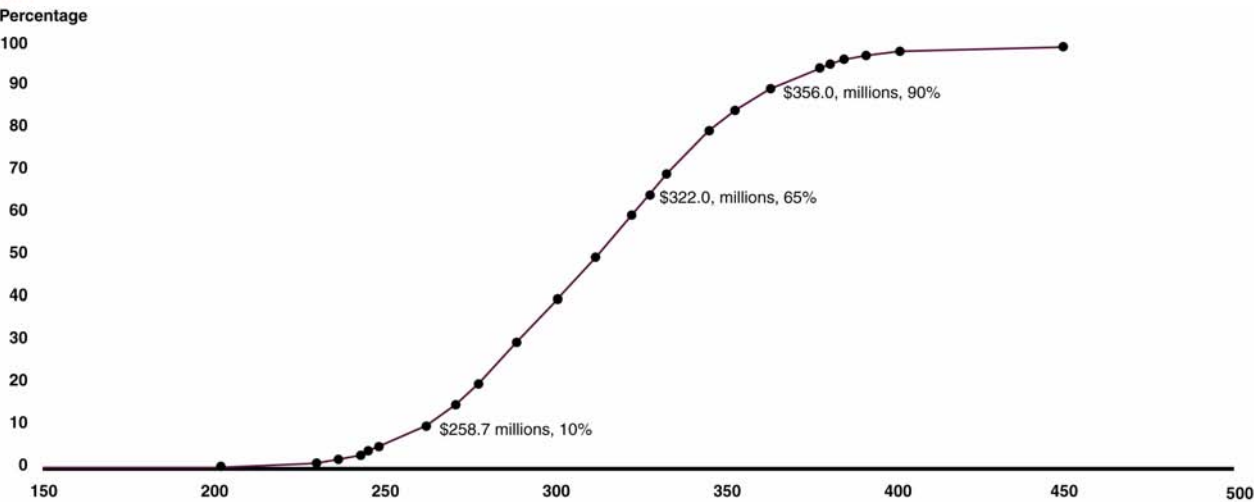


## Risk-adjusted Range: One-Time Cost

- The 65 percent confidence level estimate (\$322.0 million) is plotted, along with the 10 percent (\$258.7 million) and 90 percent (\$356.0 million) confidence levels, which when reported as a range represent an 80 percent confidence interval.
- A confidence interval describes a range of possible costs, based on a specified probability level that is determined through a risk analysis. The low and high values of the confidence interval can be expressed as confidence levels that represent the probability that the point estimate will be met. Our 80 percent confidence interval is the range of costs from the 10 percent confidence level to the 90 percent confidence level. At the 10 percent confidence level, there is a 10 percent chance that the cost will be at or below the estimate and a 90 percent chance that the cost will be above the estimate. Likewise at the 90 percent confidence level, there is a 90 percent chance that the cost will be at or below the estimate and a 10 percent chance that the final cost will be above the estimate.



# Risk-adjusted Range: One-Time Cost



Source: GAO analysis.

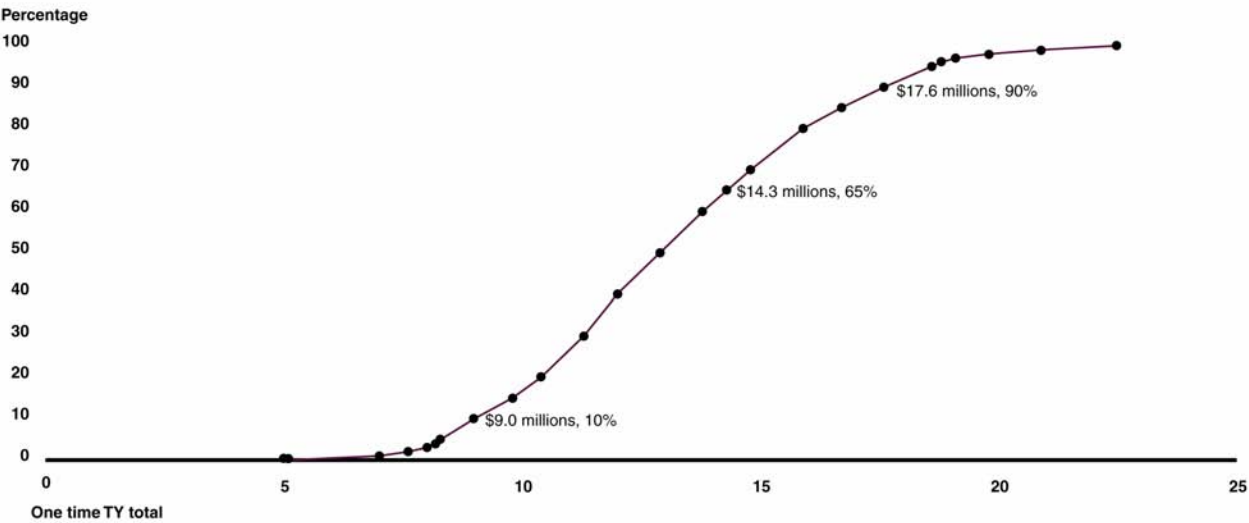


## Risk-adjusted Range: Recurring Costs

- The 65 percent confidence level estimate (\$14.3 million) is plotted, along with the 10 percent (\$9.0 million) and 90 percent (\$17.6 million) confidence levels, which when reported as a range represent an 80 percent confidence interval.



# Risk-adjusted Range: Recurring Costs



Source: GAO analysis.





## One-Time Cost Element: Planning and Design

- GAO risk-adjusted range - \$15.0 million to \$22.9 million
- GAO 65 percent confidence level estimate - \$19.7 million
- Navy point estimate - \$ 30.0 million
- The Navy's estimate is outside of GAO's risk-adjusted range. Both GAO and the Navy estimated planning and design as a percentage of the overall construction cost. The difference between the two planning and design estimates reflects the difference in the overall estimates of construction costs.



## One-Time Cost Element: Initial Dredging

- GAO risk-adjusted range - \$31.3 million to \$33.1million
- GAO 65 percent confidence level estimate - \$ 32.3 million
- Navy point estimate - \$ 46.3 million
- GAO originally used a scaled analogy based on similar dredging at Norfolk Naval Shipyard and produced an estimate similar to the Navy's. However, we have updated our estimate for dredging at Mayport to reflect the cost of the contract that was awarded in August 2010. The contract amount was \$26.6 million, and the GAO estimate includes overhead and contingency costs. The Navy stated that the contract price came in lower than the estimate due to the widely varying nature of costs in the dredging industry. According to a Navy official, the dredging price is largely based on equipment availability. If equipment happens to be available at the required time, then the dredging cost will be lower.



## One-Time Cost Element: Parking Garage

- GAO risk-adjusted range - \$21.9 million to \$53.3 million
- GAO 65 percent confidence level estimate - \$ 38.5 million
- Navy point estimate - \$ 27.8 million
- The Navy's estimate is within the GAO risk-adjusted range. GAO's estimate is based on cost per square foot, adjusted with cost factors for supervision, inspection, and overhead; contingency; and a geographic factor for northeast Florida. The Navy's estimate is based on a detailed engineering estimate developed by a private engineering firm.



## One-Time Cost Element: Road Improvements

- GAO risk-adjusted range - \$9.5 million to \$24.3 million
- GAO 65 percent confidence level estimate - \$18.4 million
- Navy point estimate - \$15.3 million
- The Navy's estimate is within GAO's risk-adjusted range. GAO's estimate is based on a scaled analogy of road construction projects for other locations. The Navy's estimate is based on a detailed engineering estimate developed by a private engineering firm.



## One-Time Cost Element: Wharf F Improvements

- GAO risk-adjusted range - \$28.3 million to \$75.3 million
- GAO 65 percent confidence level estimate - \$58.2 million
- Navy point estimate - \$38.9 million
- The Navy's estimate is within GAO's risk-adjusted range. GAO's estimate is based on an average of analogous wharf construction projects from other locations. Adjustments were made for size, geographic location, and inflation. The Navy's estimate is based on a detailed engineering estimate developed by a private engineering firm.



## One-Time Cost Element: Controlled Industrial Facility

- GAO risk-adjusted range - \$35.2 million to \$94.9 million
- GAO 65 percent confidence level estimate - \$70.5 million
- Navy estimate - \$139.1 million
- The Navy's estimate is not within GAO's risk-adjusted range. The Navy's estimate is based on a detailed engineering study developed by a private engineering firm. The GAO estimate is based on historical costs observed for analogous facility construction projects at Naval Station North Island (San Diego). These analogous costs are adjusted to account for differences in size, inflation, geographical differences between the two areas, and any identified complexities or requirements unique to the Mayport construction. Those complexity factors included construction to withstand Class 4 hurricane storm surge and costs associated with compliance with environmental standards and with antiterrorism and force protection. These factors were included in GAO's estimate based on a percentage of the total construction cost. No other specific complexity factors that would account for the discrepancy in the two estimates have been identified by either GAO or the Navy.



## One-Time Cost Element: Ship Maintenance Support Facilities

- GAO risk-adjusted range - \$23.0 million to \$59.3 million
- GAO 65 percent confidence level estimate - \$45.6 million
- Navy estimate - \$157.2 million
- The Navy's estimate is substantially outside of GAO's risk-adjusted range. The Navy's estimate is based on a detailed engineering study developed by a private engineering firm. The GAO estimate is based on historical costs observed for analogous facility construction projects at Naval Station North Island. These analogous costs are adjusted to account for differences in size, inflation, geographical differences between the two areas, and any identified complexities or requirements unique to the Mayport construction. Those complexity factors included compliance with environmental standards and with antiterrorism and force protection. These factors were included in GAO's estimate based on a percentage of the total construction cost. No other specific complexity factors that would account for the significant difference between the two estimates have been identified by either GAO or the Navy.



## One-Time Cost Element: Initial Equipment Outfitting

- GAO risk-adjusted range - \$24.5 million to \$64.4 million
- GAO 65 percent confidence level estimate - \$48.4 million
- Navy point estimate - \$73.0 million
- The Navy's estimate is outside of GAO's risk-adjusted range. GAO's estimate is based on a scaled analogy of equipment purchased at Naval Air Station North Island, San Diego. The Navy's estimate is based on a detailed estimate that lists all equipment purchase requirements, with the cost of commercial pricing estimated for each item.





## One-Time Cost Element: Initial Permanent Change of Station

- GAO risk-adjusted range - \$4.7 million to \$6.0 million
- GAO 65 percent confidence level estimate - \$5.5 million
- Navy point estimate - \$10.0 million
- The Navy's estimate is outside of GAO's risk-adjusted range. GAO's estimate is based on published DOD dislocation allowance rates, by rank, for crew members with and without dependents. It assumes a single permanent change of station move when the homeport location is changed. The Navy's estimate appears to be based on additional costs other than the dislocation allowance rates, but the exact nature of those costs was not specified.



## Recurring Cost Element: Permanently Assigned Labor

- GAO risk-adjusted range - \$0.7 million to \$1.9 million
- GAO 65 percent confidence level estimate - \$1.4 million
- Navy point estimate - \$1.2 million
- The Navy's estimate is within GAO's risk-adjusted range. GAO's estimate uses the Navy's assumption of 12 full-time employees at a rate of \$100,000 per year. We confirmed that this assumption is consistent with the staffing level and compensation for employees working at the nuclear carrier maintenance facilities at Naval Air Station North Island, San Diego. GAO's 65 percent confidence level estimate is slightly higher than the Navy's point estimate because it has been adjusted through a risk and uncertainty analysis, whereas the Navy's estimate has not.



## Recurring Cost Element: Base Operating Support

- GAO risk-adjusted range - \$0.7 million to \$1.4 million
- GAO 65 percent confidence level estimate - \$1.1 million
- Navy point estimate - \$1.0 million
- The Navy's estimate is within GAO's risk-adjusted range. GAO's estimate uses the Navy's assumptions of 10 full-time guards at \$75,000 per year and \$225,000 per year for facilities services based on a fixed unit cost per square foot. The unit cost is based on an average cost for Naval Station Mayport in fiscal year 2008. GAO's 65 percent confidence level estimate is slightly higher than the Navy's point estimate because it has been adjusted through a risk and uncertainty analysis, whereas the Navy's estimate has not.



## Recurring Cost Element: Facilities Sustainment

- GAO risk-adjusted range - \$0.7 million to \$1.2 million
- GAO 65 percent confidence level estimate - \$1.0 million
- Navy point estimate - \$0.8 million
- The Navy's estimate is within GAO's risk-adjusted range. Both estimates are based on facilities sustainment rates published in the DOD Facilities Pricing Guide, a program analysis and budget tool that lists replacement, sustainment, modernization, and operation unit costs for DOD facilities. Adjustments are made for geographic location.



## Recurring Cost Element: Facilities Restoration and Modernization

- GAO risk-adjusted range - \$2.2 million to \$3.3 million
- GAO 65 percent confidence level estimate - \$2.9 million
- Navy estimate - \$6.8 million
- The Navy's estimate is outside GAO's risk-adjusted range. GAO's estimate is based on modernization factors published in the DOD Facilities Pricing Guide. Each factor is multiplied against the estimated construction cost. The Navy's estimate assumes a 67-year recapitalization rate. The modernization factors and 67-year recapitalization rate result in very similar percentages, but because the Navy's construction estimates are higher, the restoration and modernization rates are correspondingly higher in the Navy's estimate.



## Recurring Cost Element: Operations

- GAO risk-adjusted range - \$0.5 million to \$1.4 million
- GAO 65 percent confidence level estimate - \$1.0 million
- Navy point estimate - \$0.8 million
- The Navy's estimate is within GAO's risk-adjusted range. GAO's estimate is based on the assumptions and amounts used in the Navy's estimate. GAO's 65 percent confidence level estimate is slightly higher than the Navy's point estimate because it has been adjusted through a risk and uncertainty analysis, whereas the Navy's estimate has not.



## Recurring Cost Element: Travel for Navy Shipyard Workers

- GAO risk-adjusted range - \$4.8 million to \$12.2 million
- GAO 65 percent confidence level estimate - \$9.1 million
- Navy point estimate - \$7.0 million
- The Navy's estimate is within GAO's risk-adjusted range. GAO's estimate is based on a scaled analogy of travel expenses incurred during a 2009 planned incremental availability on the *USS Ronald Reagan*. Adjustments were made for inflation and differing airfare and per diem rates in the Jacksonville, Florida area. The Navy's estimate is based on a programming model that breaks down the travel expense into component costs for airfare, per diem, hotel tax, rental car, and gas.



## Recurring Cost Element: Biennial Maintenance Dredging

- GAO risk-adjusted range - \$0.1 million to \$0.2 million
- GAO 65 percent confidence level estimate - \$0.1 million
- Navy point estimate - \$0.1 million
- The Navy's estimate is within GAO's risk-adjusted range. GAO's estimate is based on the assumptions and amounts used in the Navy's estimate. For this cost element, GAO's 65 percent confidence level estimate is identical to the Navy's point estimate even though the Navy's estimate was not adjusted through a risk and uncertainty analysis like GAO's.





## Recurring Cost Element: Basic Allowance for Housing

- GAO risk-adjusted range - \$-5.5 million to \$-4.4 million
- GAO 65 percent confidence level estimate - \$-4.8 million
- Navy point estimate - \$-3.2 million
- The Navy's estimate is outside GAO's risk-adjusted range. Both estimates are based on published rates, by rank, for crew members with and without dependents. The difference between the estimates is due to the fact that GAO's estimate assumes a crew size of 3,140, which is consistent with the Navy's Environmental Impact Study and other sources. The Navy's estimate assumes a crew size of 2,728, which lowers the total savings.
- Note: The estimate for this cost element is negative because the housing allowance is less in Jacksonville, Florida than it is in Norfolk, Virginia. This means that there is a net savings for the Navy for this cost element.



## Recurring Cost Element: Utilities

- GAO risk-adjusted range - \$0.6 million to \$1.8 million
- GAO 65 percent confidence level estimate - \$1.3 million
- Navy point estimate - \$0.8 million
- The Navy's estimate is within GAO's risk-adjusted range. Both estimates are based on the same assumed amount of power usage multiplied by an average power cost differential. GAO's estimate uses average power costs published by the Department of Energy for Virginia and Florida, which is a differential of 2.51 cents. The Navy's estimate assumes a 2.00 cent differential.



## Recurring Cost Element: Recurring Permanent Change of Station

- GAO risk-adjusted range - \$1.0 million to \$1.3 million
- GAO 65 percent confidence level estimate - \$1.2 million
- Navy point estimate - N/A
- GAO's estimate is based on the permanent change of station costs calculated as part of the one-time costs and applies that amount for all docking planned incremental availabilities and the midlife refueling complex overhaul. These costs are annualized over the 50-year carrier life cycle. The Navy's estimate does not include any permanent change of station costs associated with docking planned incremental availabilities or the midlife refueling complex overhaul.



## Recurring Cost Element: Private Sector Travel

- GAO risk-adjusted range - \$0.1 million to \$1.2 million
- GAO 65 percent confidence level estimate - \$0.6 million
- Navy point estimate - N/A
- To account for the risk that private sector shipyards may have to bring in workers from outside of the Mayport area during surges in workload and thereby incur travel expenses that would be passed on to the federal government, the GAO estimate calculates potential private sector travel costs using the public sector travel and per diem rates. The GAO estimate assumes a 60/40 public/private ratio for maintenance work in Mayport and sets the most likely private sector travel cost at zero, with a high-value risk input that assumes 30 percent of the private sector workforce has to travel from outside of the Mayport area.

# Appendix III: GAO's Assessment of the Navy's Cost Estimating Practices

Characteristic	Overall assessment	Best practice	Individual assessment
Comprehensive	Partially met	The cost estimate includes all life-cycle costs.	Substantially met
		The cost estimate completely defines the program, reflects the current schedule, and is technically reasonable.	Partially met
		The cost estimate work breakdown structure is product-oriented, traceable to the statement of work/objective, and at an appropriate level of detail to ensure that cost elements are neither omitted nor double-counted.	Minimally met
		The estimate documents all cost-influencing ground rules and assumptions.	Minimally met
Well documented	Minimally met	The documentation should capture the source data used, the reliability of the data, and how the data were normalized.	Minimally met
		The documentation describes in sufficient detail the calculations performed and the estimating methodology used to derive each element's cost.	Minimally met
		The documentation describes step by step how the estimate was developed so that a cost analyst unfamiliar with the program could understand what was done and replicate it.	Minimally met
		The documentation discusses the technical baseline description and the data in the baseline are consistent with the estimate.	Partially met
		The documentation provides evidence that the cost estimate was reviewed and accepted by management.	Partially met
Accurate	Minimally met	The cost estimate results are unbiased, not overly conservative or optimistic, and based on an assessment of most likely costs.	Not met
		The estimate has been adjusted properly for inflation.	Minimally met
		The estimate contains few, if any, minor mistakes.	Minimally met
		The cost estimate is regularly updated to reflect significant changes in the program so that it is always reflecting current status.	Minimally met
		Variances between planned and actual costs are documented, explained, and reviewed.	Not met
		The estimate is based on a historical record of cost estimating and actual experiences from other comparable programs.	Substantially met
Credible	Not met	The cost estimate includes a sensitivity analysis that identifies a range of possible costs based on varying major assumptions, parameters, and data inputs.	Not met
		A risk and uncertainty analysis was conducted that quantified the imperfectly understood risks and identified the effects of changing key cost driver assumptions and factors.	Minimally met
		Cost drivers were cross-checked to see whether results were similar.	Not met
		An independent cost estimate was conducted by a group outside the acquiring organization to determine whether other estimating methods produce similar results.	Not met

Source: GAO analysis of Navy data. GAO Cost Estimating and Assessment Guide (GAO-09-3SP).

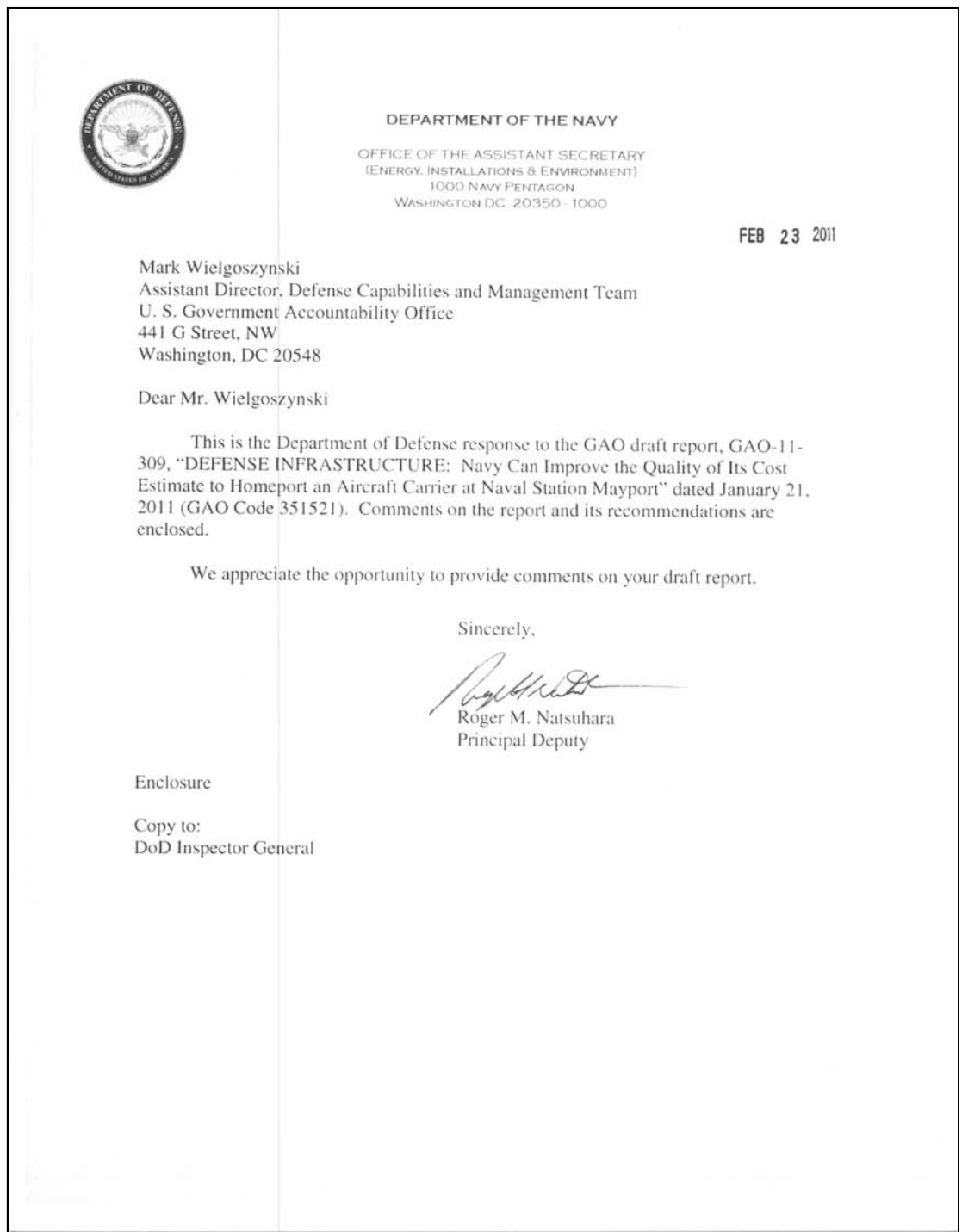
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**Appendix III: GAO's Assessment of the Navy's  
Cost Estimating Practices**

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Note: Not met means the Navy provided no evidence that satisfies any of the criterion; minimally met means the Navy provided evidence that satisfies a small portion of the criterion; partially met means the Navy provided evidence that satisfies about half of the criterion; substantially met means the Navy provided evidence that satisfies a large portion of the criterion; and met means the Navy provided complete evidence that satisfies the entire criterion.

# Appendix IV: Comments from the Department of Defense



GAO DRAFT REPORT DATED JANUARY 21, 2011  
GAO-11-309 (GAO CODE 351521)

**“DEFENSE INFRASTRUCTURE: NAVY CAN IMPROVE THE QUALITY  
OF ITS COST ESTIMATE TO HOMEPORT AN AIRCRAFT CARRIER  
AT NAVAL STATION MAYPORT”**

**DEPARTMENT OF DEFENSE COMMENTS  
TO THE GAO RECOMMENDATIONS**

**RECOMMENDATION 1:** The GAO recommends that the Secretary of Defense direct the Secretary of the Navy to take the following action: To improve the comprehensiveness of its cost estimate, the Navy should include all potential recurring costs, and clearly describe the ground rules and assumptions underlying the estimation of each cost element.

**DoD RESPONSE:** Partially concur. While the elements cited by GAO may contribute to improved quality in cost estimates, they may not be ideally suited to the myriad situations in which the Navy is required, or may be requested, to provide cost estimates to Congress, notably formal budget submissions which require the use of prescribed exhibits and where the costs will be spread across multiple appropriations and, therefore, included in multiple budget justification materials. Furthermore, Navy cost estimates used in reports to Congress typically reflect program estimates resulting from formal, disciplined programming/budgeting process. Additional Secretary of Defense direction in this regard is not required unless it applies to all Components of the Department of Defense (DoD). Details on the Navy’s process for estimating construction costs are provided in the below technical comments. Additionally, it should be noted that, for the one project which has been awarded (dredging), GAO’s initial estimate was comparable to the Navy’s. The fact that GAO’s initial dredging estimate was essentially the same as the Navy’s budget estimate suggests that refinement of Navy estimates, as they progress through the programming/budgeting process, leads to high quality, credible estimates.

**RECOMMENDATION 2:** The GAO recommends that the Secretary of Defense direct the Secretary of the Navy to take the following action: To improve the quality and transparency of the Navy’s estimate, the Navy should document the life cycle costs. Specifically documentation should: identify the source data used, its reliability, and how the data was normalized; describe the steps used in developing the overall estimate so that it can be clearly understood and easily replicated; and describe in sufficient detail the estimating methodology and calculations performed to derive each element’s cost.



**DoD RESPONSE:** Partially concur. While the elements cited by GAO may contribute to improved quality in cost estimates, they may not be ideally suited to the myriad situations in which the Navy is required, or may be requested, to provide cost estimates to Congress, notably formal budget submissions which require the use of prescribed exhibits and where the costs will be spread across multiple appropriations and, therefore, included in multiple budget justification materials. Additional Secretary of Defense direction in this regard is not required unless it applies to all DoD Components. Additionally, it should be noted that, for the one project which has been awarded (dredging), GAO's initial estimate was comparable to the Navy's. The fact that GAO's initial dredging estimate was essentially the same as the Navy's budget estimate suggests that refinement of Navy estimates, as they progress through the programming/budgeting process, leads to high quality, credible estimates.

**RECOMMENDATION 3:** The GAO recommends that the Secretary of Defense direct the Secretary of the Navy to take the following action: To improve the accuracy and credibility of its cost estimate the Navy should assign a single office with the responsibility for assembling the overall estimate into a comprehensive and well-documented package and for performing a sensitivity and risk and uncertainty analyses on the overall estimate to identify the major cost drivers, extent to which estimates could vary due to changes in key cost assumptions, and level of confidence in the estimate.

**DoD RESPONSE:** Non-concur. Responsibilities for centralized supervision and coordination of programming and budgeting within the Department of the Navy are well-established. Navy program/budget estimates and exhibits are prepared and submitted in accordance with OSD guidance. Additional Secretary of Defense direction in this regard is not required unless it applies to all DoD Components. Where such reports include cost information, it is long-standing Navy practice to report costs as contained in the official Future Years' Defense Program (FYDP) where applicable. The FYDP is the culmination of the aforementioned programming/budgeting process. Additionally, reports to Congress are typically assigned to a central office for preparation and coordination (which may include the compilation of inputs from other offices). Where necessary, instructions to offices providing inputs can include guidance on baseline assumptions (e.g., then year versus constant dollars) to ensure consistency.

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# Appendix V: GAO Contact and Staff Acknowledgments

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## GAO Contact

Brian J. Lepore, Director, (202) 512-4523 or [leporeb@gao.gov](mailto:leporeb@gao.gov)

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## Acknowledgments

In addition to the contact listed above, key contributors to this report include Mark J. Wielgoszynski, Assistant Director; Darnita Akers; Shawn Arbogast; David Brown (Technomics, Inc.); Russell Bryan; Jennifer Echard; Mary Jo LaCasse; Erik Wilkins-McKee; and Michael Shaughnessy.

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